Fish and Wildlife Habitat Status and Trends in the Canadian Watershed of Lake Ontario

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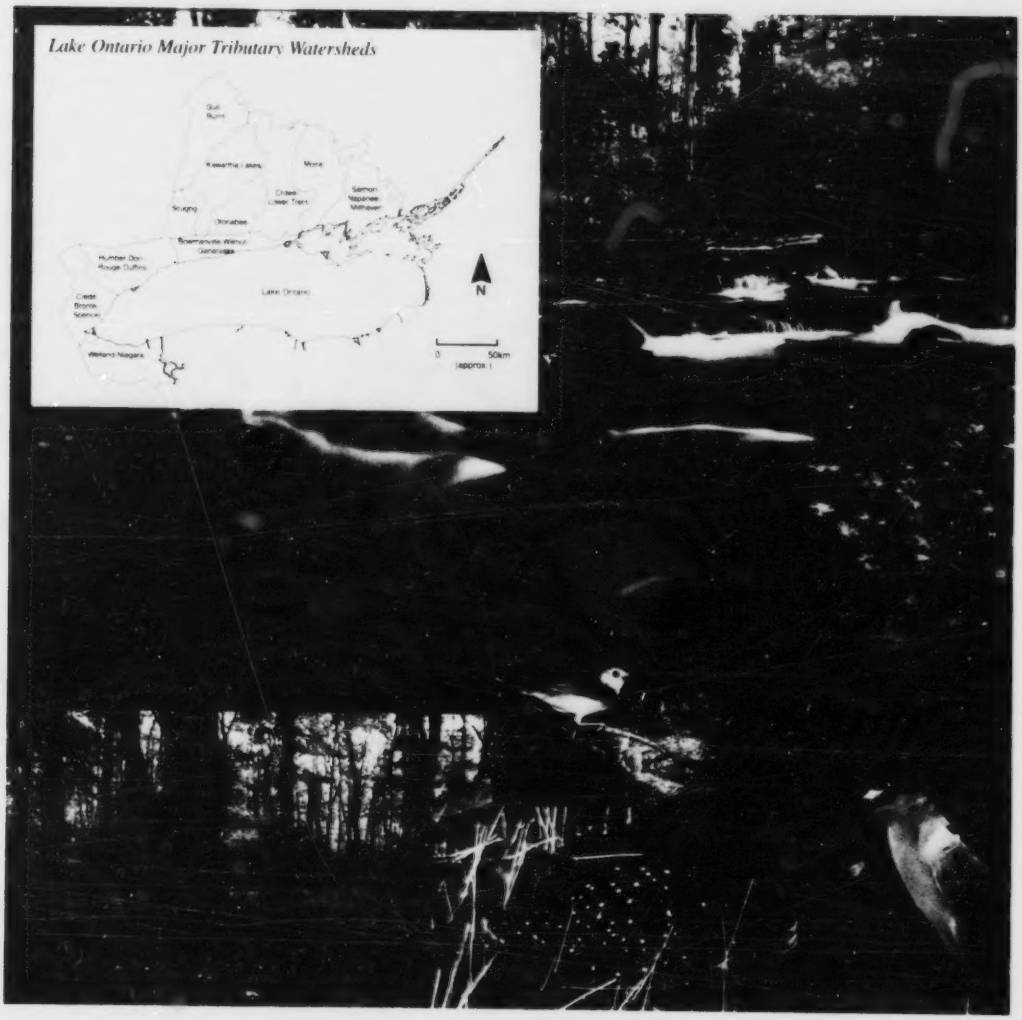

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Executive Summary

The development of Lakewide Management Plans (LaMPs) for each of the Great Lakes includes a commitment to "embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses." The Lake Ontario LaMP process includes a habitat objective: "Lake Ontario offshore and nearshore zones and surrounding tributary, wetland, and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for the health, productivity, and distribution of plants and animals in and adjacent to Lake Ontario."

This report examines the current status of habitats on the Canadian side of Lake Ontario and its watershed, and recent trends affecting those habitats. It also identifies recent habitat rehabilitation and protection projects and programs.

Lake Ontario watershed:

The Lake Ontario watershed is 3.4 times the area of the lake itself, the largest land-to-lake ratio of any of the Great Lakes. Its physiography is diverse, characterized by fertile farmlands in the southern and western sections, and forested Canadian Shield habitats in the north. The following status and trend factors are significant:

- *Woodland loss has been substantial in the watershed south of the Shield, but woodlands are regenerating, especially in the eastern counties.*
- *Forest cover has been fragmented in many parts of the watershed to levels that do not support the full range of native wildlife, and fragmentation is continuing.*
- *Historic wetland losses have been significant within the watershed, especially in the western and southern sections.*
- *Significant remaining wetland concentrations are associated with the Peterborough drumlin field, the edge of the Canadian Shield, and the Niagara Escarpment.*
- *The area of grassland habitats has stabilized but grassland birds are declining in most parts of the watershed.*
- *The highest priority habitats for assemblages of forest birds occur in the northern sections of the Lake Ontario watershed.*
- *Designated Important Bird Areas are primarily located along the Lake Ontario coast.*
- *Rare vegetation communities occur in clusters along the Niagara Escarpment and in the Northumberland-Hastings area.*
- *Rare species are distributed broadly across the Lake Ontario watershed, with a particular concentration in the Niagara region.*

Several stressors on watershed habitats are examined:

- *Most human population growth has been on the urban fringe.*
- *Most of the future population growth will be within the Greater Toronto Area and the Hamilton to Niagara region.*

- *Rural areas have fewer farmers and more non-farm residents than in previous years.*
- *Despite urban growth, agriculture and forestry still dominate land use within the Lake Ontario basin.*
- *Both urban and rural land uses are changing relatively rapidly in response to urban sprawl, loss of employment in city centres, and loss of farmland.*
- *The number of farms and total area farmed are dropping, while average farm size is rising.*
- *Farming practices are more intensive in the western third of the watershed; intensity has changed little in the past two decades.*
- *The total amount of pesticide use on Ontario farms is declining.*
- *Levels of most airborne pollutants affecting the Lake Ontario basin are stable or declining, with the exception of ground-level ozone.*
- *Climate change has the potential to create enormous future stress on the natural forest ecosystems of the watershed.*
- *Invasive exotic (non-native) species affect the quality of upland habitats, particularly within urban areas.*

Significant habitats remain in the Lake Ontario watershed, though many habitats are degraded and under continuing stress. Major rehabilitation programs would be necessary to achieve the habitat rehabilitation objectives identified for Areas of Concern across the rest of the landscape.

Lake Ontario tributaries:

Canadian tributaries to Lake Ontario contribute only about seven percent of its annual water inputs, but act as principal spawning and nursery habitats for one-third of the fish species in the Lake, and significantly increase biodiversity in other ways. Tributaries include the large Trent-Severn Waterway system, a series of short, steep streams rising from the Oak Ridges Moraine, and lower-gradient warmwater systems in the Niagara area.

Among the significant status and trends findings for tributaries are:

- *Few streams south of the Canadian Shield meet the habitat rehabilitation guidelines for riparian cover in Areas of Concern.*
- *Most tributary streams south of the Shield have impaired fish communities relative to their historic potential.*
- *Several species of threatened and vulnerable fish occur within Lake Ontario tributary streams.*

Stressors on tributary streams show a mix of encouraging trends and persistent problems:

- *Over the past 26 years, suspended sediment loadings in most tributaries have declined significantly.*
- *Most toxic contaminants in the six tributaries being monitored meet Provincial Water Quality Objectives.*
- *Increased streamflow variability is associated with intensive agricultural and urban land uses within the watershed.*
- *Stream baseflows and water quality are at risk from urbanization and excessive groundwater taking.*
- *Climate change will exacerbate existing stressors on aquatic ecosystems in coming years.*
- *Dams and other barriers have disrupted fish movement, changed habitat conditions, and prevented genetic dispersal.*

Overall, habitats within tributary streams are significantly degraded. While much of this degradation is long-standing, habitat conditions are improving slowly, but new stressors threaten this progress.

Nearshore lands and waters:

The shoreline area where land and water interact is a dynamic and productive part of the ecosystem, but also an area that has attracted intensive human use. Six Canadian shore zones on Lake Ontario show considerable variability, with the Outlet basin having only 20 percent of the Lake's area but 50 percent of its shoreline length because of its shoreline complexity. The ongoing evolution of shoreline habitats is largely controlled by the substrate making up the main body of the nearshore lakebed in each area.

Many of the nearshore habitats in Lake Ontario are poorer in quality and diversity now than at the time of European settlement, due to a series of historic alterations and abuses. In the recent past, their status and trends can be summarized as:

- *Terrestrial habitats in a natural state are in very limited supply along the shoreline and are declining further.*
- *Many occurrences of special lakeshore natural communities lack long-term protection from alteration.*
- *A majority of shoreline wetlands have been destroyed by past human activities, and remaining wetlands are threatened by habitat alteration, water level controls, and sedimentation.*
- *Populations of most colonial nesting waterbirds have increased, in some species dramatically, as contaminant loads have dropped.*

- *While suitable nesting habitat for ospreys and bald eagles exists in the eastern section of the shoreline, widespread nesting has not yet resumed.*
- *Seasonal waterfowl use along the shore has changed, generally increasing, likely in response to zebra mussel populations.*
- *Fish and aquatic communities in at least some degraded nearshore areas have recovered significantly.*

Among the current stressors on nearshore lands and waters are:

- *Management of lake levels since 1960 has reduced the degree of year-to-year fluctuation and degraded natural shoreline processes.*
- *Shoreline hardening and artificial structures have impaired natural erosion and sediment transport processes in the western sections of the Lake.*
- *Nearshore loadings of nutrients and toxic contaminants have declined significantly over the past four decades, but remain above target levels in some areas.*
- *The continued introduction and population growth of non-native species is affecting the stability of nearshore natural ecosystems, with uncertain long-term results.*
- *Climate change could cause nearshore habitat changes at a rate faster than the ecosystem's capacity to respond.*

Overall, most of the serious degradation of the nearshore area is a legacy of historic practices, with considerable improvement in recent years related to control of nutrients and toxic contaminants. However, the combined stressors of shoreline land use, lake level controls, and non-native species continue to hold back the recovery of the nearshore zone.

Offshore waters of Lake Ontario:

Because Lake Ontario has a relatively deep, smooth-sided basin, features such as water temperature and oxygen levels play a major role in defining offshore habitat conditions. Food webs include a pelagic or open-water web and a benthic or bottom-related web. By the 1960s, most of the native fish species populations in the offshore area had been extirpated or severely depressed as a result of overfishing, habitat destruction, exotic species introductions, and nutrient enrichment. Recent years have seen marked improvements, with the ability to catch large salmon in Lake Ontario symbolizing the recovery of the Lake for many people. Its current status and trends include:

- *Phosphorus and other nutrient levels have declined markedly over the past 30 years, and related effects such as improved water clarity are currently being exaggerated by zebra and quagga mussels.*
- *Offshore pelagic fish communities have become very unstable in response to changing habitat conditions and predator-prey relationships, especially related to alewife abundance.*

- *Offshore benthic fish communities have shown recent improvements, but the impact of zebra and quagga mussels makes further improvement uncertain.*
- *Phytoplankton and zooplankton community structure and abundance are shifting in response to phosphorus reductions and mussel invasion.*
- *The abundance of benthic organisms in offshore areas has declined significantly since the 1960s, and changes in species composition have occurred recently.*

Current stressors in the offshore zone can be summarized as:

- *Nutrient levels are no longer problematic, but the role of toxic contaminants in the offshore benthic environment needs further assessment.*
- *Exotic species almost completely dominate offshore communities and their management, and additional new exotics may threaten biodiversity further.*

Overall, offshore habitats and communities can be characterized as much improved but very unstable, as the impacts of recent stressors and population changes continue to reverberate through the ecosystem.

Habitat rehabilitation efforts:

Over the past decade, a large number of habitat rehabilitation projects have been carried out in the Lake Ontario watershed, many of them in association with the Bay of Quinte, Toronto and Region, Hamilton Harbour, and Niagara River Remedial Action Plans. These projects include:

- *ten major wetland rehabilitation projects associated with the Great Lakes Wetlands Conservation Action Plan;*
- *dozens of individual projects, large and small, undertaken with the financial support of the Great Lakes 2000 Cleanup Fund (now succeeded by the Great Lakes Sustainability Fund), including wetland rehabilitation, stream or riparian habitat enhancement, strategic planning studies to guide habitat rehabilitation, and shoreline habitat rehabilitation projects;*
- *at least 35 projects supported through the Action 21 and EcoAction 2000 programs, which included rehabilitation efforts directed towards riparian/watershed areas, wetlands and shorelines, endangered species or communities, urban habitats, and environmental monitoring;*
- *a wide variety of community-level projects including Community Wildlife and Community Fisheries Involvement Programs, fisheries management plans, conservation authority rehabilitation projects, tree planting programs, Wetland Habitat Fund projects, watershed report cards, and Ducks Unlimited Canada projects; and*

- *agricultural programs including Environmental Farm Plans, Best Management Practices, Rural Conservation Clubs, Wetland/Woodlands/Wildlife program, Ontario LandCARE, and increased usage of reduced tillage or no-till techniques.*

There is a very broad mix of government and non-government activity addressing rehabilitation of various habitats, however, the projects being undertaken are often uncoordinated, small-scale, and opportunistic at the present time.

Habitat conservation efforts:

Even though the Lake Ontario watershed continues to be seriously deficient in protected areas, some progress has been made in habitat conservation in recent years through:

- *expansion of the system of provincial parks and conservation reserves, and management of other public lands including the Trent-Severn Waterway, provincial Crown lands, national and provincial wildlife areas, 36 000 hectares of conservation authority lands, county and regional forests, and a mix of designation by other public agencies;*
- *identification of Environmentally Significant Areas and other protective land use planning designations under the Provincial Natural Heritage Policy in about half of upper-tier municipalities and some lower-tier municipalities;*
- *policy protection for habitats of provincial interest, including Areas of Natural and Scientific Interest, wetlands, and Niagara Escarpment natural areas, with less site-specific provincial interest also expressed for the Lake Ontario shoreline and the Oak Ridges Moraine;*
- *continued activity by conservation authorities in regulation of sensitive areas and development of watershed and shoreline management plans;*
- *a variety of other designations and planning processes, such as World Biosphere Reserves, Niagara Escarpment Plan, Important Bird Areas, National Marine Conservation Areas, and the Carolinian Canada Big Picture planning process;*
- *private land stewardship programs in many parts of the watershed, including landowner contact programs for significant habitats, property tax incentives through the Conservation Lands Tax Reduction Program, the development of community-based land trust organizations, and the introduction of enhanced federal incentives for donation of ecologically sensitive lands; and*
- *a broad range of ecological monitoring programs, including many that are volunteer-based.*

While a mix of national and provincial parks, conservation areas, and other public lands protect significant habitats, the Lake Ontario watershed is deficient in protected areas to represent its full range of habitat types.

Conclusions:

Lake Ontario and the lands that drain into it have seen a history of significant abuse. While the ecosystem has shown a remarkable capacity to repair the damage, new forms of human-caused stressors keep appearing. Habitats of the future are likely to be less rich in species and interactions, less resilient, and less able to endure further abuse unless ways can be found to replicate and improve upon the successes of the past three decades to provide some degree of relief from the cumulative effects of these stressors. Taken at a glance, the status of the four broad habitat zones shows a mix of progress in addressing past issues, but a daunting array of current challenges:

	Watershed	***Tributaries***	***Nearshore***	***Offshore***
Current Habitat Status	*Significantly degraded*	*Significantly degraded*	*Significantly degraded*	*Mostly recovered*
Recent Trend	*Stable to declining*	*Stable on average*	*Partial recovery but unstable*	*Increasing instability*
Major Issues	*Forest loss and fragmentation; grassland and interior forest birds declining*	*Increasing flow variability; urban stormwater; dams*	*Limited supply of terrestrial habitats; shore hardening; zebra mussels*	*Non-native fish communities; rapid changes in benthic and pelagic life*
Significant Stressors				
Land Use Change	✓	✓	✓	
Physical Modifications	✓	✓	✓	
Toxic Contamination		✓	✓	✓
Exotic Species	✓		✓	✓
Climate Change	✓	✓	✓	

Programs to respond to these stressors have been successful in reducing phosphorus and contaminant loadings, but have yielded uneven results and a generally lower level of success in addressing other habitat stressors. While interest is increasing in addressing such issues as large blocks of forest, species and communities at risk, urban streams, and hardened shorelines, relatively little on-the-ground rehabilitation has taken place. Habitat conservation programs, especially on private lands, can be considered only partially effective.

Climate change and exotic species invasion could be viewed as future super-stressors, with the potential to overwhelm progress to date and seriously destabilize the Lake Ontario ecosystem. Based on the analysis of habitat status and trends in the Canadian Lake Ontario watershed, a

number of recommendations have been made to: enhance existing programs and encourage new ones; broaden the scope of habitat rehabilitation and protection in the basin; improve coordination and data collection mechanisms; and support a management framework for cooperative activities.

Résumé

L'élaboration de plans d'aménagement panlacustre (PAP) pour chacun des Grands Lacs comprend un engagement à "procéder d'une démarche systématique englobant la totalité de l'écosystème afin de restaurer et de protéger les utilisations". Le processus du PAP du lac Ontario comporte également un objectif concernant les habitats, à savoir que les zones côtières et de pleine eau du lac Ontario ainsi que les habitats des terres hautes, des milieux humides et des tributaires environnants soient d'une qualité et d'une quantité suffisantes pour soutenir les objectifs d'écosystème en matière de santé, de productivité et de distribution des espèces végétales et animales dans le lac Ontario et à proximité de celui-ci.

Le présent rapport examine l'état actuel des habitats du côté canadien du lac Ontario et dans son bassin hydrographique ainsi que les tendances récentes ayant une incidence sur ces habitats. Il souligne également les projets et programmes récents de remise en valeur et de protection des habitats.

Bassin hydrographique du lac Ontario

- *La perte de terres boisées a été substantielle dans le bassin hydrographique, au sud du Bouclier, mais on assiste présentement à leur rétablissement, particulièrement dans les comtés de l'est.*
- *La couverture forestière, qui a été fragmentée dans de nombreuses parties du bassin hydrographique, ne peut plus maintenant soutenir toute la gamme d'espèces sauvages indigènes; cette fragmentation se poursuit.*
- *Les pertes de milieux humides historiques ont été significatives dans le bassin hydrographique, particulièrement dans les parties ouest et sud.*
- *D'importantes concentrations de milieux humides intacts subsistent dans le champ de drumlins de Peterborough, au bord du Bouclier canadien et à la hauteur de l'escarpement du Niagara.*
- *La superficie des habitats de prairie s'est stabilisée, mais les oiseaux de prairie déclinent un peu partout dans le bassin hydrographique.*
- *Les habitats hautement prioritaires pour leur richesse en oiseaux forestiers se trouvent dans le nord du bassin hydrographique du lac Ontario.*
- *Les régions désignées importantes pour les oiseaux sont situées principalement le long du lac Ontario.*
- *Les communautés végétales rares sont présentes par grappes le long de l'escarpement du Niagara et dans la région de Northumberland-Hastings.*
- *Les espèces rares sont distribuées de façon générale à la grandeur du bassin hydrographique du lac Ontario, une concentration particulière étant présente dans la région de Niagara.*

Plusieurs agents stressants des habitats du bassin hydrographique sont examinés.

- *La majeure partie de la croissance démographique humaine se produit en milieu périurbain.*
- *La majeure partie de la croissance démographique future aura lieu dans la région métropolitaine torontoise ainsi que dans l'intervalle englobant Hamilton et Niagara.*
- *Les régions rurales présentent moins d'agriculteurs et davantage de résidents non agriculteurs que par le passé.*
- *Malgré la croissance urbaine, l'agriculture et la foresterie dominent toujours au chapitre de l'utilisation des terres dans le bassin du lac Ontario.*
- *Les utilisations des terres urbaines et rurales évoluent assez rapidement en raison de l'étalement urbain, de la perte d'emplois dans les centres urbains et de la perte de terres agricoles.*
- *Le nombre d'exploitations agricoles et la superficie agricole totale diminuent, même si la taille moyenne des fermes augmente.*
- *Les pratiques agricoles sont plus intensives dans le tiers ouest du bassin hydrographique. L'intensité a peu varié au cours des deux dernières décennies.*
- *La quantité totale de pesticides utilisés sur les fermes ontariennes est à la baisse.*
- *Les concentrations de la plupart des polluants atmosphériques affectant le bassin du lac Ontario sont stables ou à la baisse, à l'exception de l'ozone troposphérique.*
- *Les changements climatiques pourront perturber considérablement les écosystèmes forestiers naturels du bassin hydrographique.*
- *Les espèces exotiques (non indigènes) envahissantes affectent la qualité des habitats des hautes terres, particulièrement dans les zones urbaines.*

D'importants habitats subsistent dans le bassin hydrographique du lac Ontario, bien que nombre de ceux-ci soient détériorés et soumis constamment à des agents stressants. Il faudrait mettre en œuvre des programmes de remise en valeur d'envergure pour atteindre les objectifs de rétablissement des habitats indiqués pour les secteurs préoccupants du reste de la région.

Tributaires du lac Ontario

Les tributaires canadiens du lac Ontario n'assurent qu'environ 7 % de l'apport en eau annuel. Ils représentent toutefois d'importants habitats de fraye et de croissance pour un tiers des espèces halieutiques du lac et accroissent la biodiversité de façon significative. Parmi les tributaires, mentionnons la voie navigable Trent-Severn, une série de cours d'eau lotiques (c.-à-d. à écoulement rapide) provenant de la moraine de Oak Ridges et un réseau hydrographique à eaux plus chaudes à faible pente dans la région de Niagara.

Voici certains des principaux constats sur l'état et les tendances des tributaires.

- *Peu de cours d'eau au sud du Bouclier canadien sont conformes aux lignes directrices en matière de remise en valeur des habitats pour ce qui est du couvert riverain dans les secteurs préoccupants.*
- *La plupart des tributaires au sud du Bouclier renferment des communautés halieutiques appauvries comparativement à leur potentiel historique.*
- *Plusieurs espèces de poissons menacées et vulnérables sont présentes dans les tributaires du lac Ontario.*

Les agents stressants affectant les tributaires présentent un mélange de tendances encourageantes et de problèmes persistants.

- *Au cours des 26 dernières années, les charges de sédiments en suspension dans la plupart des tributaires ont décliné de façon significative.*
- *Les concentrations de la plupart des contaminants toxiques présents dans les six tributaires surveillés respectent les objectifs provinciaux en matière de qualité de l'eau.*
- *La variabilité accrue du débit des tributaires est associée à une utilisation agricole et urbaine intensive dans le bassin hydrographique.*
- *Les débits de base des cours d'eau et la qualité de l'eau sont menacés par l'urbanisation et l'exploitation excessive des nappes souterraines.*
- *Les changements climatiques accentueront les agents stressants qui affectent présentement les écosystèmes aquatiques.*
- *Les barrages et autres obstacles ont perturbé le mouvement des poissons, modifié l'état des habitats et nui à la diversité génétique.*

Dans l'ensemble, les habitats des tributaires sont détériorés de façon significative. Même si cette détérioration se fera sentir longtemps, l'état des habitats s'améliore lentement. Toutefois, de nouveaux agents stressants pourraient freiner ces progrès.

Terres et eaux côtières

La zone côtière où la terre et l'eau interagissent constitue une partie dynamique et productive de l'écosystème. Toutefois, il s'agit également d'une zone fortement utilisée par l'homme. Six zones côtières canadiennes du lac Ontario présentent une variabilité considérable. Ainsi, le secteur en aval du lac, qui n'affiche que 20 % de la superficie lacustre totale, représente 50 % du kilométrage côtier en raison de la complexité du littoral. L'évolution continuelle des habitats côtiers est en grande partie fonction du substrat qui constitue le lit du lac à proximité du littoral dans chaque zone.

À l'heure actuelle, nombre des habitats côtiers du lac Ontario affichent une qualité et une diversité médiocres comparativement à l'époque de l'arrivée des Européens, en raison d'un ensemble d'altérations et d'atteintes au fil des ans. Dans un passé rapproché, leur état et les tendances s'y rapportant pouvaient être résumés de la manière suivante.

- *Les habitats terrestres à l'état naturel sont en nombre très limité le long du littoral et affichent toujours un déclin.*
- *De nombreuses communautés naturelles côtières spéciales ne bénéficient pas d'une protection à long terme contre l'altération.*
- *Une majorité des milieux humides côtiers ont été détruits par l'homme. Les milieux humides qui restent sont menacés par la dégradation de l'habitat, la régulation des niveaux d'eau et la sédimentation.*
- *La population de la plupart des espèces d'oiseaux aquatiques nicheurs vivant en colonie s'est accrue et ce, de façon spectaculaire chez certaines espèces, en raison de la forte diminution des charges de contaminants.*
- *Même si le balbuzard pêcheur et le pygargue à tête blanche trouvent un habitat de nidification approprié dans la section est du littoral, la nidification ne s'est pas encore rétablie dans l'ensemble du bassin hydrographique.*
- *L'utilisation saisonnière du littoral par la sauvagine s'est modifiée, en général à la hausse, probablement à cause de la présence de la moule zébrée.*
- *Les communautés halieutiques et aquatiques dans au moins certaines zones littorales dégradées se sont rétablies de façon significative.*

Voici certains des agents stressants qui affectent les terres et les eaux côtières.

- *La régulation des niveaux du lac amorcée en 1960 a réduit le degré de fluctuation annuelle et a dégradé les processus côtiers naturels.*
- *La consolidation des rives et les structures artificielles ont ralenti l'érosion naturelle et les processus de transport de sédiments dans les sections ouest du lac.*
- *Les charges d'éléments nutritifs et de contaminants toxiques à proximité des rives ont décliné de façon significative au cours des quatre dernières décennies, mais demeurent supérieures aux concentrations cibles dans certaines régions.*
- *L'introduction continue d'espèces exotiques et la croissance de ces populations affectent la stabilité des écosystèmes littoraux naturels; les résultats à long terme sont incertains.*
- *Les changements climatiques pourraient engendrer des modifications aux habitats littoraux plus rapides que la vitesse à laquelle l'écosystème peut s'adapter.*

Dans l'ensemble, la majeure partie de la détérioration marquée de la zone littorale résulte de pratiques passées. Toutefois, une amélioration considérable a été réalisée ces dernières années au chapitre de l'élimination des éléments nutritifs et des contaminants toxiques. Par contre, les agents stressants combinés que sont l'utilisation des terres côtières, la régulation des niveaux du lac et l'introduction d'espèces exotiques continuent à ralentir le rétablissement de la zone littorale.

Zones de pleine eau

Comme le lac Ontario présente un bassin relativement profond aux pentes peu abruptes, la température de l'eau et les concentrations d'oxygène, entre autres, jouent un rôle majeur dans la définition des conditions des habitats de pleine eau. Les réseaux trophiques comprennent un réseau pélagique (en eau libre) ainsi qu'un réseau benthique (fond). Dans les années 1960, la plupart des populations halieutiques indigènes vivant dans la zone de pleine eau ont été épuisées ou fortement affaiblies par la surpêche, la destruction des habitats, l'introduction d'espèces exotiques et l'enrichissement en éléments nutritifs. Les dernières années ont été marquées par des améliorations, la présence de grands salmonidés dans le lac Ontario symbolisant le rétablissement du lac pour de nombreuses personnes. L'état actuel et les tendances peuvent notamment être décrits comme suit.

- *Les concentrations de phosphore et d'autres éléments nutritifs ont affiché une baisse marquée au cours des 30 dernières années. Les effets connexes de cette amélioration (plus grande clarté de l'eau, etc.) sont présentement bien mis en évidence par la prolifération des moules zébrées et les moules quagga.*

- *Les communautés de poissons pélagiques de la zone de pleine eau sont devenues très instables en raison de la modification de l'état de l'habitat et des relations prédateur-proie, particulièrement en ce qui concerne l'abondance du gaspareau.*

- *Les communautés de poissons benthiques de la zone de pleine eau ont affiché des améliorations dernièrement, mais la présence des moules zébrées et des moules quagga pourrait mettre ces progrès en péril.*

- *La structure et l'abondance du phytoplancton et du zooplancton évoluent à la suite de la réduction des concentrations de phosphore et de l'invasion des moules.*

- *L'abondance des organismes benthiques dans la zone de pleine eau a diminué de façon significative depuis les années 1960, et des changements dans la composition des espèces se sont produits récemment.*

Les agents stressants actuels qui effectent la zone de pleine eau peuvent se résumer comme suit.

- *Les concentrations d'éléments nutritifs ne sont plus un problème, mais le rôle des contaminants toxiques dans l'environnement benthique de la zone de pleine eau doit être étudié davantage.*

- *Les espèces exotiques, que l'on parvient mal à gérer, dominent presque complètement les communautés de la zone de pleine eau; l'introduction de nouvelles espèces exotiques pourrait poser une nouvelle menace à la biodiversité.*

Dans l'ensemble, on peut dire que les habitats et les communautés de la zone de pleine eau se sont grandement améliorés, mais sont très instables du fait que des agents stressants récents et les changements dans les populations continuent d'avoir une incidence sur l'ensemble de l'écosystème.

Efforts de remise en valeur de l'habitat

Au cours de la dernière décennie, un nombre important de projets de remise en valeur de l'habitat ont été menés dans le bassin hydrographique du lac Ontario. Nombre d'entre eux ont été réalisés en collaboration avec les responsables des plans d'assainissement de la baie de Quinte, de la région du Grand Toronto, du port de Hamilton et de la rivière Niagara. Ces projets englobent les points suivants.

- *Dix grands projets de remise en valeur des milieux humides associés au Plan d'action en matière de conservation des terres humides des Grands Lacs.*

- *Des douzaines de projets distincts, de petite ou de grande envergure, entrepris avec le soutien financier du Fonds d'assainissement du programme des Grands Lacs 2000 (remplacé maintenant par le Fonds pour la pérennité des Grands Lacs), et portant notamment sur la restauration des milieux humides, l'amélioration des habitats riverains et fluviaux, la réalisation d'études de planification stratégique pour orienter la remise en valeur des habitats et l'exécution de projets de restauration des habitats côtiers.*

- *Au moins 35 projets soutenus par les programmes Action 21 et ÉcoAction 2000, et portant notamment sur la remise en valeur de zones du bassin hydrographique et de zones riveraines, de milieux humides et de rivages, d'espèces ou de communautés menacées et d'habitats urbains ainsi que sur la surveillance environnementale.*

- *Un vaste éventail de projets communautaires, y compris le Programme de participation communautaire à la gestion de la faune, le Programme de participation communautaire à la gestion des pêches, des plans de gestion des pêches, des projets de remise en valeur des offices de protection de la nature, des programmes de plantation d'arbres, des projets soutenus par l'Ontario Wetland Habitat Fund, la réalisation de fiches de rendement du bassin hydrographique et des projets de Canards Illimités Canada.*

- *Des programmes agricoles, y compris les Plans agroenvironnementaux, les pratiques de gestion optimales, les clubs ruraux de protection de l'environnement, le Programme des terres marécageuses, des terrains boisés et de la faune et le programme Ontario LandCARE ainsi qu'un recours accru au travail réduit du sol et à la culture sans labour.*

Il existe un très vaste éventail d'activités gouvernementales et non gouvernementales concernant la remise en valeur de divers habitats. Toutefois, les projets entrepris manquent souvent de coordination, et sont souvent à petite échelle et de nature opportuniste.

Efforts de conservation des habitats

Même si le bassin hydrographique du lac Ontario affiche toujours une grave pénurie de zones protégées, certains progrès ont été accomplis ces dernières années en matière de conservation des habitats par l'entremise des moyens suivants.

- *Élargissement du réseau de parcs provinciaux et de réserves de conservation et gestion d'autres terres publiques, y compris la voie navigable Trent-Severn, les terres publiques provinciales, des réserves fauniques nationales et provinciales, 36 000 hectares de terres relevant d'offices de protection de la nature, des forêts de comté et des forêts régionales ainsi que par l'entremise d'un ensemble de désignations par d'autres organismes publics.*

- *Détermination des zones importantes et sensibles sur le plan environnemental et attribution d'autres désignations pour la planification d'utilisations respectueuses des terres en vertu de la politique provinciale sur le patrimoine naturel dans près de la moitié du palier supérieur des instances municipales et dans certaines instances du palier inférieur.*

- *Protection, par l'entremise de politiques, d'habitats d'intérêt provincial situés en bordure du lac Ontario et dans la moraine de Oak Ridges et affichant des intérêts provinciaux moins spécifiques au site, dont des zones d'intérêt naturel et scientifique, des milieux humides, des zones naturelles de l'escarpement du Niagara.*

- *Action continue des offices de protection de la nature concernant la réglementation des zones sensibles et l'élaboration de plans de gestion du bassin hydrographique et du littoral.*

- *Utilisation de diverses autres désignations et processus de planification, comme les réserves de la biosphère, le plan de l'escarpement du Niagara, les régions importantes pour les oiseaux, les aires marines nationales de conservation et le processus de planification de la vue d'ensemble de la région carolinienne canadienne.*

- *Exécution de programmes de bonne intendance des terres privées dans de nombreuses parties du bassin hydrographique, y compris des programmes de sensibilisation des propriétaires fonciers concernant des habitats importants, des incitatifs fiscaux par le truchement du Programme de réduction fiscale sur les terres protégées, la mise sur pied de fiducies foncières communautaires et l'instauration, par le gouvernement fédéral, de mesures incitatives améliorées pour le don de terres importantes sur le plan écologique.*

- *Exécution d'un vaste éventail de programmes de surveillance écologique, y compris de nombreux programmes faisant appel à des bénévoles.*

Même si un amalgame de parcs nationaux et provinciaux, de réserves et d'autres terres publiques protègent les habitats importants, le bassin hydrographique du lac Ontario n'a pas suffisamment de zones protégées pour représenter sa gamme complète d'habitats.

Conclusion

Le lac Ontario et les terres qui s'y drainent ont subi de très graves atteintes. Même si l'écosystème a affiché une résilience remarquable, de nouveaux agents stressants anthropiques continuent de surgir. Dans l'avenir, les habitats seront vraisemblablement moins riches en espèces et en interactions et seront caractérisés par une capacité de régénération et une résilience plus faibles. Il faudra donc trouver des moyens pour reproduire les réussites des trois dernières décennies, qui ont permis un certain allégement des effets cumulatifs des agents stressants, et pour poursuivre dans cette veine. En bref, on peut dire que les quatre grandes zones d'habitat font l'objet de nombreux projets destinés à résoudre les problèmes antérieurs, mais qu'un important ensemble d'enjeux continue de se poser.

	Bassin hydrographique	**Tributaires**	**Zone côtière**	**Zone de pleines eaux**
État actuel de l'habitat	*Détérioré de façon significative*	*Détériorés de façon significative*	*Détériorée de façon significative*	*Remise en valeur en grande partie*
Tendances récentes	*Stable à déclinant*	*Stables en moyenne*	*Remise en valeur partielle, mais instable*	*Instabilité croissante*
Problèmes majeurs	*Perte et fragmentation des forêts; oiseaux des prairies et des forêts intérieures en déclin*	*Variabilité accrue du débit; eaux pluviales urbaines, barrages*	*Approvisionnement limité des habitats terrestres; consolidation des rives; moules zébrées*	*Communautés halieutiques exotiques; évolution rapide de la vie benthique et pélagique*
Agents stressants importants				
Changement de l'utilisation des terres	✓	✓	✓	
Modifications physiques	✓	✓	✓	
Contamination par les substances toxiques		✓	✓	✓
Espèces exotiques	✓		✓	✓
Changements climatiques	✓	✓	✓	

Les programmes d'intervention contre les agents stressants ont permis de réduire les charges de phosphore et de contaminants, mais ont donné des résultats inégaux et, en général, se sont révélés moins efficaces vis-à-vis d'autres agents stressants qui affectent les habitats. Même si l'on s'intéresse de plus en plus aux grands blocs forestiers, aux espèces et aux communautés en péril, aux cours d'eau urbains et aux rives consolidées, on constate que relativement peu d'initiatives de remise en valeur sont menées concrètement. Les programmes de conservation

des habitats, particulièrement sur les terres privées, ne semblent donner que des résultats partiels.

Les changements climatiques et l'invasion des espèces exotiques peuvent être considérés comme des agents stressants majeurs de l'avenir. Ils pourront annuler les progrès réalisés à ce jour et déstabiliser gravement l'écosystème du lac Ontario. On a formulé, d'après l'analyse de l'état et des tendances concernant les habitats du bassin hydrographique canadien du lac Ontario, un certain nombre de recommandations : améliorer les programmes actuels et favoriser l'élaboration de nouveaux programmes; élargir la portée des activités de protection et de remise en valeur des habitats dans le bassin; améliorer la coordination de collecte des données et les mécanismes employés à cette fin; soutenir un cadre de gestion pour les activités menées en collaboration.

Table of Contents

Executive Summary i

Résumé ix

Table of Contents xix

List of Figures xxii

List of Tables xxiii

Acknowledgments xxiv

Glossary of Acronyms xxv

1.0 Introduction

1.1 Background on the Lake Ontario LaMP Process 1

1.2 Habitat in the Context of the Great Lakes Ecosystem 3

2.0 Lake Ontario Watershed

2.1 Habitat Characteristics and Historical Changes 5

2.2 Defined Habitat Goals for the Watershed 9

2.3 Current Status and Recent Trends 11
Forest Cover 11
Wetlands 16
Grassland Habitats 21
Priority Bird Habitats 22
Natural Communities at Risk 27
Species at Risk 30

2.4 Current Stressors and Impacts 33
Human Population Growth 33
Land Use 38
Trends in Agriculture 40
Airborne Stressors 43
Exotic Species 45

2.5 Summary of Impairment, Information Gaps and Emerging Issues 46

3.0 Lake Ontario Tributaries

3.1 Habitat Characteristics and Historical Changes 47

3.2 Defined Habitat Goals for Tributaries 50

3.3 Current Status and Recent Trends 51
Riparian Cover
Health of Fish Communities

3.4 Current Stressors and Impacts 55
Loadings of Sediments and Toxins
Variability in Flow
Climate Change
Aquatic Habitat Fragmentation

3.5 Summary of Impairment, Information Gaps, and Emerging Issues 63

4.0 Nearshore Lands and Waters

4.1 Habitat Characteristics and Historical Changes 64

4.2 Defined Habitat Goals for Nearshore Lands and Waters 69

4.3 Current Status and Recent Trends 71
Terrestrial Shoreline Habitats
Coastal Wetlands
Coastal Birds
Fish and Aquatic Communities

4.4 Current Stressors and Impacts 82
Lake Level Regulation
Shoreline Hardening
Nutrients and Contaminants
Exotic Species
Climate Change

4.5 Summary of Impairment, Information Gaps, and Emerging Issues 91

5.0 Offshore Waters of Lake Ontario

5.1 Habitat Characteristics and Historical Changes 92

5.2 Defined Habitat Goals for Offshore Lake Ontario 95

5.3 Current Status and Recent Trends 97
Nutrient Levels
Fish and Aquatic Communities

5.4 Current Stressors and Impacts 100
Nutrient and Toxic Contaminant Inputs
Exotic Species

5.5 Summary of Impairment, Information Gaps, and Emerging Issues 102

6.0 Overview of Current Habitat Rehabilitation Efforts 103

6.1 Great Lakes Wetlands Conservation Action Plan 104

6.2 Great Lakes 2000 Cleanup Fund 105

6.3 Great Lakes Sustainability Fund 108

6.4 Action 21/EcoAction 2000 Projects 108

6.5 Other Habitat Rehabilitation Programs 112

6.6 Agricultural Programs 115

6.7 Summary Assessment of Habitat Rehabilitation Programs 117

7.0 Overview of Current Habitat Conservation Efforts 118

7.1 Parks and Public Lands 118

7.2 Planning Initiatives 121
Municipal Plans and Environmentally Significant Areas
Natural Habitats of Provincial Interest
Conservation Authority Programs
Other Designations and Planning Processes

7.3 Private Land Stewardship 128

7.4 Ecological Monitoring 130

7.5 Summary Assessment of Habitat Conservation Programs 132

8.0 Conclusions 133

References 137

List of Figures

1. Counties and regions in the Lake Ontario watershed 2
2. Major tributary watersheds in the Lake Ontario watershed 3
3. Physiographic regions in the Lake Ontario watershed 6
4. Site districts in the Lake Ontario watershed 7
5. Woodland extent and changes in Lake Ontario watershed counties (moving west to east) 12
6. Heritage woodlands in the Lake Ontario watershed 14
7. Historic wetland extent from pre-settlement to 1982 18
8. Conversion of original wetland area in Lake Ontario watershed townships 19
9. Evaluated wetlands in the Lake Ontario watershed 20
10. Grassland as a percent of land area in the Lake Ontario watershed 22
11. Patterns of species richness for priority birds and Important Bird Areas 27
12. Habitat associations of 61 rare vegetation community types 28
13. Occurrences of rare vegetation communities in the Lake Ontario watershed 29
14. Distribution of provincially rare species in the Lake Ontario watershed 32
15. Population growth in Lake Ontario watershed counties: 1976 to 1996 33
16. Percentage population change: 1981 to 1996 35
17. Projected population growth to 2021 36
18. Farm and rural populations in Lake Ontario watershed counties 37
19. Land use in the Lake Ontario Canadian watershed 38
20. Changes in farm number and size: 1981 to 1996 41
21. Percent of active farmland under crops: 1996 42
22. Pesticide use on Ontario farms: 1998 43
23. Riparian habitat conditions for selected Lake Ontario streams 52
24. Coldwater stream habitats accessible from Lake Ontario 54
25. Suspended sediment loadings: 1972 to 1998 56
26. Tributary watershed sediment yields: 1970s to 1990s 57
27. Lake Ontario Canadian shore zones 65
28. Percent of shoreline habitats: Lake Ontario Canadian shoreline 67
29. Percent of Lake Ontario shoreline land use (Canadian side only) 72
30. Number of gull, tern and cormorant nests: Lake Ontario Canadian colonies 77
31. Trends in waterfowl use of Lake Ontario Canadian nearshore waters 79
32. Lake Ontario water levels: 1918 to 1999 84
33. Shoreline hardening on Lake Ontario 85
34. PCB concentrations in herring gull eggs from Lake Ontario colonies: 1970 to 1999 87
35. Bathymetry of Lake Ontario 93
36. Sedimentation basins of Lake Ontario 94
37. Ducks Unlimited Canada and Eastern Habitat Joint Venture of the North American Waterfowl Management Plan projects in the Lake Ontario watershed between 1977 and 1999 114
38. Use of reduced tillage and no-till 116
39. Provincially significant Areas of Natural and Scientific Interest in the Lake Ontario watershed 125

List of Tables

1. Habitat rehabilitation guidelines for Great Lakes Areas of Concern 9
2. Comparison of recent percent forest cover estimates 13
3. Forest interior at the county level 15
4. Forest interior conditions within selected Area of Concern watersheds 16
5. Provincially Significant Wetlands (PSWs) in the Lake Ontario watershed 21
6. List of priority birds in the Lake Ontario watershed 24
7. Distribution of rare species occurrences in the Lake Ontario watershed 30
8. Population distribution by population density class: 1981 to 1996 34
9. Area of cropland as a percent of total census farm area: Lake Ontario watershed counties 42
10. Summary of riparian habitat rehabilitation guidelines for Great Lakes Areas of Concern 50
11. Flow responsiveness of Lake Ontario tributaries 59
12. Shore zone characteristics of Lake Ontario: Niagara to Kingston 66
13. Summary of special lakeshore natural features and designations 73
14. Historic coastal wetland losses along the Lake Ontario shoreline 75
15. Summary of basin characteristics of Lake Ontario 92
16. Action 21 / EcoAction 2000 projects in the Lake Ontario watershed 109
17. Provincial Parks in the Lake Ontario watershed 118
18. Enduring feature representation in the Lake Ontario watershed 120
19. Environmentally Significant Area surveys in the Lake Ontario watershed 124
20. Conservation Authority lands, watershed plans, and shoreline plans 127
21. Participation in Conservation Lands Tax Reduction Program 129
22. Summary of habitat status, trends, and stressors for habitat zones 133

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Glossary of Acronyms

ANSI: Area of Natural and Scientific Interest

AOC: Area of Concern

BIA: Biodiversity Investment Area

BioMAP: Biological Monitoring and Assessment Program

BSC: Bird Studies Canada

CFIP: Community Fisheries Involvement Program

CLOCA: Central Lake Ontario Conservation Authority

CLTRP: Conservation Lands Tax Reduction Program

COSEWIC: Committee on the Status of Endangered Wildlife in Canada

CWIP: Community Wildlife Involvement Program

CWS: Canadian Wildlife Service

DDE: dichlorodiphenyldichloroethylene

DDT: dichlorodiphenyltrichloroethane

EHJV: Eastern Habitat Joint Venture

ESA: Environmentally Significant Area

FON: Federation of Ontario Naturalists

GLWCAP: Great Lakes Wetlands Conservation Action Plan

HCB: Hexachlorobenzene

IADN: Integrated Atmospheric Deposition Network

IBA: Important Bird Area

IBI: Index of Biotic Integrity

IJC: International Joint Commission

LaMP: Lakewide Management Plan

Glossary of Acronyms (cont.)

LOC: Lake Ontario Committee

NCC: The Nature Conservancy of Canada

NHIC: Natural Heritage Information Centre

NMCA: National Marine Conservation Area

NRVIS: Natural Resource Values Information System

OMNR: Ontario Ministry of Natural Resources

OMOE: Ontario Ministry of Environment

PCBs: polychlorinated biphenyls

PSW: provincially significant wetland

PWQO: Provincial Water Quality Objectives

RAP: Remedial Action Plan

SOLEC: State of the Lakes Ecosystem Conference

TNC: The Nature Conservancy

TRCA: Toronto and Region Conservation Authority

1.0 Introduction

1.1 Background on the Lake Ontario LaMP Process

A commitment to develop a Lakewide Management Plan (LaMP) for each of the five Great Lakes formed part of the *1987 Protocol to the Great Lakes Water Quality Agreement* signed by the governments of Canada and the United States. According to this Protocol, "LaMPs shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses..."

A Stage 1 LaMP document for Lake Ontario, which was intended to outline the "problem definition" for impairment of the Lake ecosystem, was released in 1998 (Environment Canada *et al.* 1998a). The Lake Ontario LaMP process is intended to incorporate earlier binational work carried out as part of the Lake Ontario Toxics Management Plan, as well as link to other natural resource management activities, such as the fish-community objectives for the Lake established by the Great Lakes Fishery Commission.

Three ecosystem goals for Lake Ontario were outlined in the Stage 1 LaMP document:

- The Lake Ontario Ecosystem should be maintained and as necessary restored or enhanced to support self-reproducing diverse biological communities.
- The presence of contaminants shall not limit the uses of fish, wildlife, and waters of the Lake Ontario basin by humans and shall not cause adverse health effects in plants and animals.
- We as a society shall recognize our capacity to cause great changes in the ecosystem and we shall conduct our activities with responsible stewardship for the Lake Ontario basin.

These goals were supported by five preliminary objectives, relating to aquatic communities, wildlife, human health, habitat, and stewardship. For this report, the habitat objective is most relevant:

- Lake Ontario offshore and nearshore zones and surrounding tributary, wetland, and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for the health, productivity, and distribution of plants and animals in and adjacent to Lake Ontario.

Among the Lakewide Impairments listed in the Stage 1 LaMP document was the loss of fish and wildlife habitat for a wide range of native fish and wildlife species. The causes listed for this loss included: artificial lake level management; the introduction of exotic species (non-native); and the physical loss, modification, and destruction of habitat.

This report summarizes the nature and extent of this habitat loss and causative factors in four broad zones – the watershed (Figure 1), tributaries (Figure 2), nearshore lands and waters, and offshore waters. In doing so, it provides information wherever possible on trends over time, on comparative values in different parts of the lake ecosystem, and on comparisons with specific habitat targets or goals that have been defined by various agencies. For each habitat zone, a summary of current impairment, information gaps, and emerging issues is provided as well.

This report also identifies remedial actions that have taken place in the recent past, or are ongoing. This includes both habitat rehabilitation projects of various kinds, and a range of habitat protection measures from outright public ownership to private land stewardship.

It is hoped that this analysis will assist in identifying future needs and priorities in order to achieve the Lake Ontario LaMP habitat objective and ecosystem goals outlined above.

Figure 1. Counties and regions in the Lake Ontario watershed

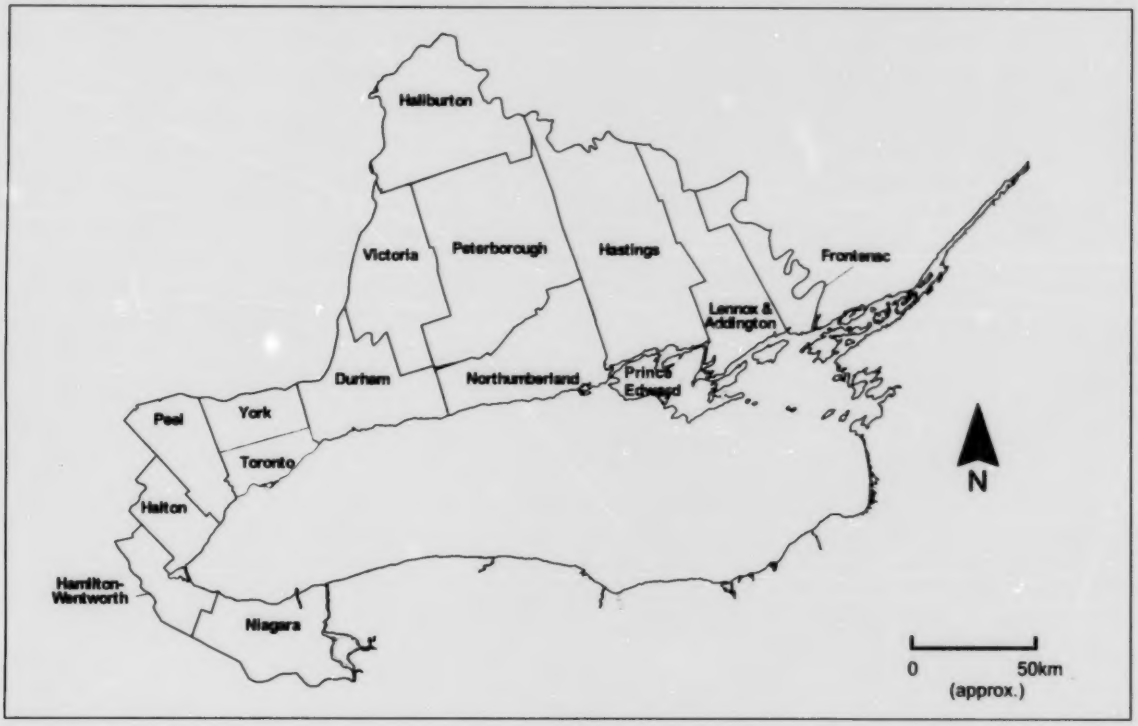
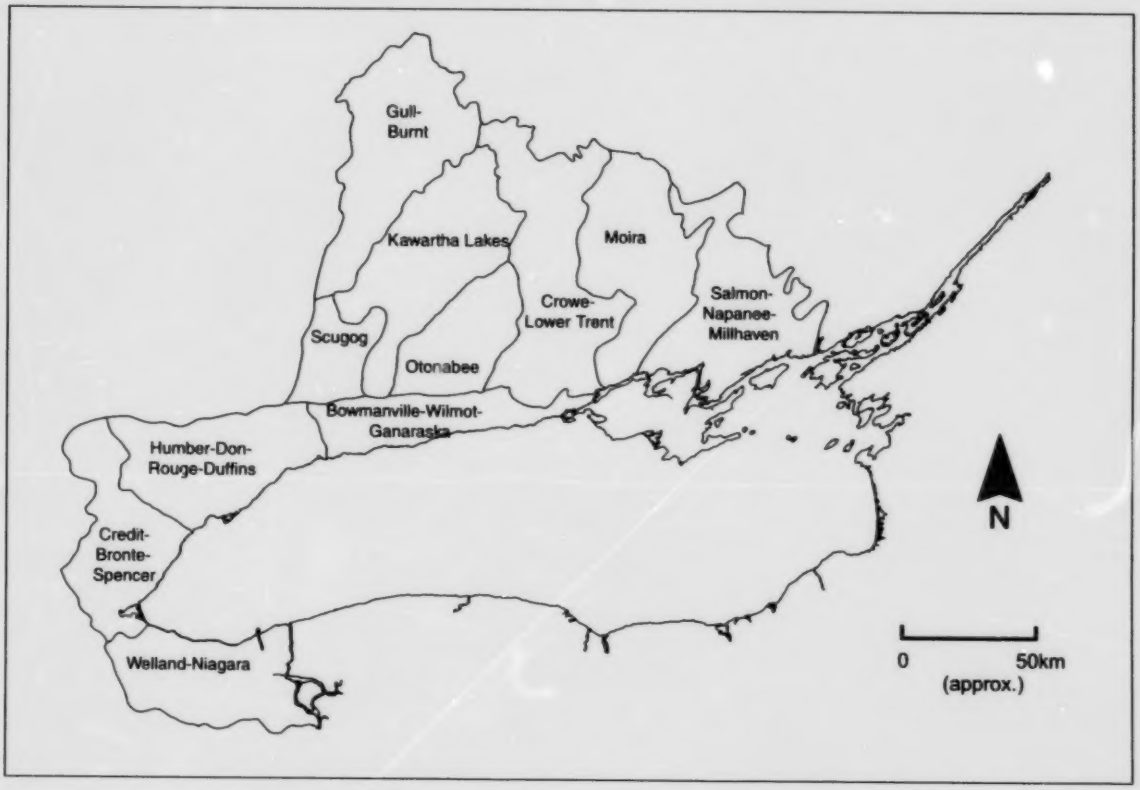


Figure 2. Major tributary watersheds in the Lake Ontario watershed



1.2 Habitat in the Context of the Great Lakes Ecosystem

The Great Lakes system is one of the world's most remarkable ecosystems, with nearly 20 percent of the earth's fresh water. Geologically, this is a very young feature, having emerged from the glaciers only 14 000 years ago. Species that have evolved here have done so in a remarkably short period of time. Many species and community types are at the margins of their ranges here, and are the most likely to respond to environmental pressures by evolving into new life forms. The lakes and surrounding landscapes are a dynamic environment, and the processes that support the adaptation of life forms need to be safeguarded (The Nature Conservancy 1994).

The Nature Conservancy (1994) has identified seven types of habitat features in the Great Lakes ecosystem which have special biodiversity features.

These include:

- the open lakes, unique in the world in their size and temperate setting, covering a third of the basin area and greatly affecting its climate; including several endemic fish species (most now thought to be extinct), such as blue pike and several species of ciscoes;

- the coastal shore system, dominated by and adapted to the effects of the lakes, with alongshore sand transport and fluctuating water levels as key ecological processes; nearly 30 percent of the globally significant biodiversity elements occurring within the basin are associated with the coast, including such communities as dunes and beaches, alvars, and bedrock shores;

- the coastal marsh system, a focal point for biological productivity and diversity, but with relatively few rare species; dominated by large lake processes, including water level fluctuations, wave action, and sand transport;

- the lakeplain system, former lakebeds with low topography, often poor drainage, and rich soils; supports 22 percent of the globally significant biodiversity features, including lakeplain prairies and savannas;

- the tributary and connecting channel systems, which are critical linkages between upland areas and the lakes; support a diversity of rare fish, native mussels, and invertebrates;

- the inland terrestrial system, which includes numerous forest types as well as barrens, prairies and bedrock; very important for groundwater regulation and sediment inputs; and

- the inland wetland system, diverse in nature and often highly productive; important storage systems and regulators for nutrients and drainage waters.

Within these habitat types, coastal shores, coastal marshes, and lakeplains were identified as having the highest relative significance, based on an assessment of biodiversity significance, uniqueness, quality-viability, and provision of ecological services to other systems.

All of these habitat elements and their values occur within Lake Ontario and its Canadian watershed. In this report, several of these classes have been combined, but their individual significance is reflected in each section.

2.0 Lake Ontario Watershed

2.1 Habitat Characteristics and Historical Changes

The Lake Ontario watershed is approximately 3.4 times the area of the lake itself, the largest land to lake ratio of any of the Great Lakes (Environment Canada *et al.* 1988). Within the Canadian watershed, a diversity of physiographic regions (Chapman and Putnam 1984) strongly affect the habitat characteristics and historic land use and this diversity is reflected in Site Districts (Figure 3 and Figure 4). These regions include:

- Fairly level and fertile till plains form a nearshore band around the western end of the Lake and follow eastwards into Northumberland County (Site Districts 7E-4, 6E-13). The abandoned Lake Iroquois shoreline ridge can be traced through much of this region, roughly parallel to the current shore. This band along the Lake enjoys a milder climate than much of the watershed, and supports Carolinian vegetation and wildlife typical of regions to the south. This region has been intensively modified for human use, initially for agriculture, and increasingly as the primary urban area within the watershed.

- The Niagara Escarpment rises steeply from these plains in a continuous ribbon of dolostone outcroppings running parallel to the lakeshore in Niagara Region and then northwards from Hamilton (Site District 7E-3). The steep slopes and shallow soils associated with the Escarpment have retained more forest than adjacent regions, and this area has significant hydrological and habitat values.

- In the area south of the Escarpment in Niagara Region, the Haldimand clay plain (Site District 7E-2) has many sections of former wetland that have been drained for agriculture, but still several significant wetland habitats exist. The vegetation and wildlife of this area are Carolinian in nature.

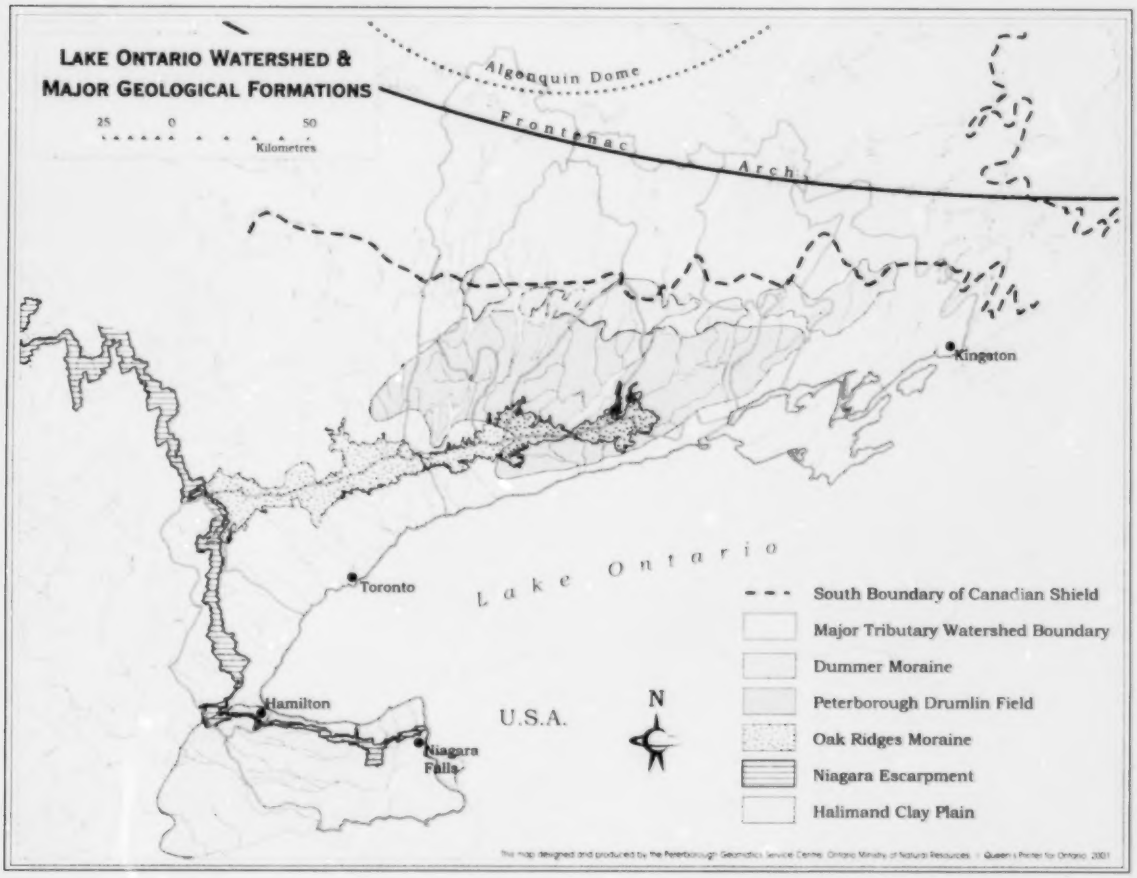
- A band of till moraines and kame moraines form the western and central sections of the watershed, rising in elevation several hundred metres above the lake level (Site District 6E-7). The Oak Ridges Moraine, which stretches eastwards from the Niagara Escarpment almost to the Trent River, is a significant complex of groundwater recharge zones, forested habitats, kettle lakes and wetlands, and other habitats.

- From the Oak Ridges Moraine northwards to the Kawartha Lakes, the Peterborough drumlin field (Site District 6E-8) and the Dummer Moraine (Site District 6E-9) encompass an area of steep-sided hills and abundant wetlands, with mixed farms and considerable forest.

- Near the eastern end of Lake Ontario, including Prince Edward County and the Napanee Plain, shallow limestone plains support mixed farming operations (Site District 6E-15). This area is relatively mild, but has greater winter snowfalls than elsewhere in the Canadian Lake Ontario basin.

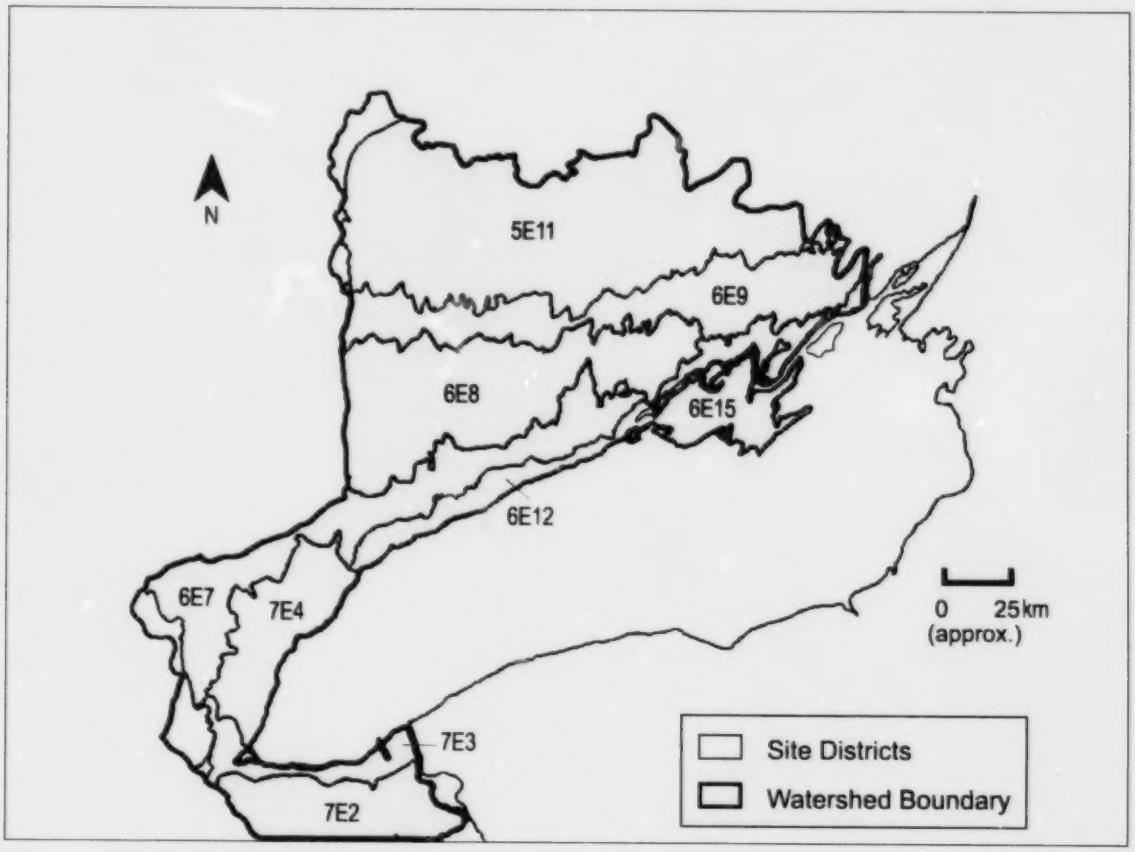
- In the northern and far eastern sections of the watershed, the ancient acidic rocks of the Canadian Shield rise in elevation onto the Algonquin dome (Site District 5E-11). Along

Figure 3. Physiographic regions in the Lake Ontario watershed



the southern edge of the Shield, including an arch called the Frontenac Axis just east of Kingston, soils are shallow and bedrock is exposed. Further north, a mix of glacial till covers the bedrock. The majority of the Shield area is forested, but almost all is routinely harvested for timber and pulp wood.

Figure 4. Site Districts in the Lake Ontario watershed



The pre-settlement condition of all of these landscapes was primarily forested. At the time of European settlement, over 90 percent of southern Ontario was forested, with about 64 percent of that as upland forest (Riley 1999). Several hundred years earlier, Aboriginal peoples such as the Iroquois cultivated some localized areas, estimated to be up to a maximum of 5.2 percent of the land south of the Canadian Shield (Campbell and Campbell 1994). By the year 1800, most of these areas had regrown into mature forest, with replacement of canopy trees mostly occurring through gap regeneration (Frelich and Reich 1996).

As an approximation of the original forests in the central parts of the Great Lakes basin, in two remaining old-growth northern hardwood forests in Michigan, about 90 percent of the trees are more than 120 years old. In contrast, by the mid-1980s, only 0.07 percent of southern Ontario hardwood forests contain trees which are older than 120 years (Ontario Ministry of Natural Resources 1987).

Clearing of the land for agriculture began relatively early along the Lake Ontario shoreline, with the first wave of United Empire Loyalists in the early 1800s. By the end of that century, most of the agricultural areas had been cleared, and logging for pine and other highly-valued species was intensive on the Canadian Shield, particularly in areas where logs could be floated downriver. Settlement and logging activities increased the frequency and severity of wildfires, and repeated burns led to soil sterilization in some areas and to a lower diversity and density of trees. Areas of sandy soils, such as the upper Ganaraska watershed, were particularly subject to wind erosion after clearing.

The low point in the history of southern Ontario forests was around 1920 (Riley 1999). Since then, the abandonment of marginal farmland, fencing of livestock, and government-sponsored tree-planting programs have increased the area of forest significantly. However, repetitive tree-cutting has resulted in simplified species composition, few veteran trees remaining for wildlife, and reduced forest crown height. On average, southern Ontario woodlands are becoming more and more immature, with the average age of stands south and east of the Shield now between 47 and 53 years old. Old growth woodland, especially on upland sites, is now so rare as to be essentially extinct in southern Ontario (Riley 1999).

In 1800, wetland habitats in southern Ontario (those found off the Shield) occupied an estimated 28.2 percent of the land area, with individual counties in the Lake Ontario basin ranging from less than 10 percent to over 36 percent wetland (Snell 1987). On the Shield, original wetland distribution was relatively sparse, averaging 10.8 percent. From 1800 to 1982, these Shield wetlands dropped to 9.6 percent, while the southern off-Shield wetlands dropped to 8.3 percent (Snell 1987).

Four major types of wetland habitats occur within the Lake Ontario basin, with approximately 86 percent of the 1982 wetlands being forested. Most of these are swamps, with some treed bogs on the Shield. Unforested wetlands include marshes, which are most common in the eastern parts of the watershed such as Prince Edward County, bogs and a few fens, which mostly occur on the Shield (Snell 1987).

Tall-grass prairie and related savanna and sand barren habitats occurred at the time of European settlement in pockets south of Rice Lake, along the Trent River, and near the lakeshore in the Toronto and Hamilton areas (Catling *et al.* 1992; Catling and Catling 1993; Bakowsky and Riley 1994; Rodger 1998). Some of these open areas, most notably the Rice Lake plains, were quite extensive, and probably maintained by periodic burning. Only a few remnants of these habitats remain intact; across southern Ontario, prairie and savanna remnants are estimated at less than three percent of their original extent (Rodger 1998). Within the overall Lake Ontario basin, the remnant extent is probably even lower.

Alvar habitats, which occur on shallow limestone and host a considerable number of rare species and communities, are found within the Lake Ontario watershed primarily on the

Napanee Plain, with a few other sites in the Trent River valley and on the Flamborough Plain (Catling and Brownell 1995; Reschke *et al.* 1999). While alvar habitats are thought to have always been sparsely distributed across the Great Lakes basin, their current extent of approximately 11 200 hectares of remaining habitat of reasonable quality is approximately 10 percent of their original area. The International Alvar Conservation Initiative (Reschke *et al.* 1999) and an Ontario theme study on alvars (Brownell 2000) identify priority alvar sites for conservation purposes.

2.2 Defined Habitat Goals for the Watershed

At present, there are no habitat goals defined specifically for the Lake Ontario watershed. However, the framework of guidelines developed for Great Lakes Areas of Concern (AOCs) (Environment Canada *et al.* 1998b) provides several guidelines which could have application across much of the watershed. These guidelines which were developed for individual watersheds (not the entire basin) include:

Table 1: Habitat rehabilitation guidelines for Great Lakes Areas of Concern

Wetland Habitat Guidelines	
Percent wetlands in watershed and subwatersheds	Greater than 10% of each major watershed in wetland habitat; greater than 6% of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
Amount of natural vegetation adjacent to the wetland	Greater than 240 metre width of adjacent habitat that may be herbaceous or woody vegetation.
Wetland type	The only two wetland types suitable for widespread rehabilitation are marshes and swamps.
Wetland location	Headwater areas for groundwater recharge, floodplains for flood attenuation, and coastal wetlands for fish production.
Wetland size	Swamps should be as large as possible to maximize interior forest habitat. Marshes of various sizes attract different species and a range of sizes is beneficial across a landscape.
Wetland shape	Swamps should be regularly shaped with minimum edge and maximum interior habitat. Marshes thrive on interspersion, a term describing the irregular shape of functional marsh habitats.
Forest Habitat Guidelines	
Percent forest cover	30% of watershed should be in forest cover.
Size of largest forest patch	At least one 200 hectare forest patch which is a minimum 500 metres wide.

Forest Habitat Guidelines (cont.)	
Percent of watershed forest cover 100/200 metres from edge	Greater than 10 percent forest cover 100 metres from edge; greater than 5 percent forest cover 200 metres from edge.
Forest shape and proximity to other forested patches	Forest patches should be circular or square in shape and in close proximity (i.e., less than two kilometres) to adjacent patches.
Fragmented landscapes and the role of corridors	Corridors designed to facilitate species movement should be a minimum of 100 metres wide and corridors designed for specialist species should be a minimum of 500 metres wide.
Forest quality: species composition and age structure	Watershed cover should be representative of the full diversity of species composition and age structure found in that ecoregion.

The recommended approach to the evaluation of significant woodlands in the *Ontario Natural Heritage Reference Manual for Policy 2.3 of the Provincial Policy Statement* (Ontario Ministry of Natural Resources 1999b) uses similar standards, with the addition of consideration of woodland diversity, uncommon characteristics, and economic and social values. These guidelines link the size of significant woodlands specifically to the amount of woodland in the surrounding landscape, recommending that woodlands be considered for significance in the following ranges:

- two hectares or larger where woodlands cover less than five percent of the land;
- four hectares or larger where woodlands cover between about five percent and 15 percent of the land; and
- forty hectares or larger (preferably 300 metres in width) where woodlands cover between about 15 percent to 30 percent of the land.

The Reference Manual also provides guidance on evaluating other natural heritage features and areas included under the *Provincial Policy Statement*, including:

- significant wetlands;
- significant portions of the habitat of endangered and threatened species;
- fish habitat;
- significant valleylands;
- significant wildlife habitat; and
- significant Areas of Natural and Scientific Interest (ANSIs).

In most cases, the evaluation process for these features and areas is based on descriptive factors, rather than numerical targets. However, it does include reference to wildlife use of various-sized habitat patches for forest, marsh, and grassland/savanna, recognizing that a range of larger patch sizes is essential to support the full range of wildlife species.

In some parts of the Lake Ontario watershed, local landscape targets have been identified through watershed plans or rehabilitation strategies. For example, long-term targets for habitat within the Don River watershed have been identified as 10 percent woodlands (except 15 percent in Vaughan), one half percent wetlands, and five percent meadows (Don Watershed Regeneration Council 1997). These targets are reflective of the predominantly urban nature of this watershed, and may be appropriate for other previously urbanized areas.

2.3 Current Status and Recent Trends

Forest Cover

Woodland loss has been substantial in the watershed south of the Shield, but woodlands are regenerating, especially in the eastern counties.

Before European settlement, southern Ontario was overwhelmingly forested, with the exception of open marsh and prairie areas. Within the upper parts of the Lake Ontario watershed, on the Canadian Shield, mixed Great Lakes-St. Lawrence forest is still the dominant land cover. A recent study prepared by the Federation of Ontario Naturalists traces the history of forest extent south of the Shield (Larson *et al.* 1999). The following are among its findings for southern Ontario as a whole.

- Clearing of forests from 1850 to 1920, primarily for agriculture, led to a low point for woodland extent of approximately 10.6 percent of the land base in 1920. Since that time, regeneration of woodland to 19.1 percent in 1978 has taken place, with an additional 6.4 percent in scrubland.

- Southern Ontario's "original woodlands" – those that have never been converted to agriculture but have been managed continuously for forestry* occupy less than six percent of the land base, and are continuing to decline. The increase in forest cover is "replacement forest" – either natural regeneration or conifer plantations.

- Only 0.07 percent of the production forest in southern Ontario is currently in an old-growth state, defined as greater than 120 years old.

- In its original state, approximately 64 percent of the land base was upland forest. These drier sites, well-suited to agriculture or building, have been particularly affected by forest clearing. By 1978, the overall loss in upland woodland since settlement was about 80 percent.

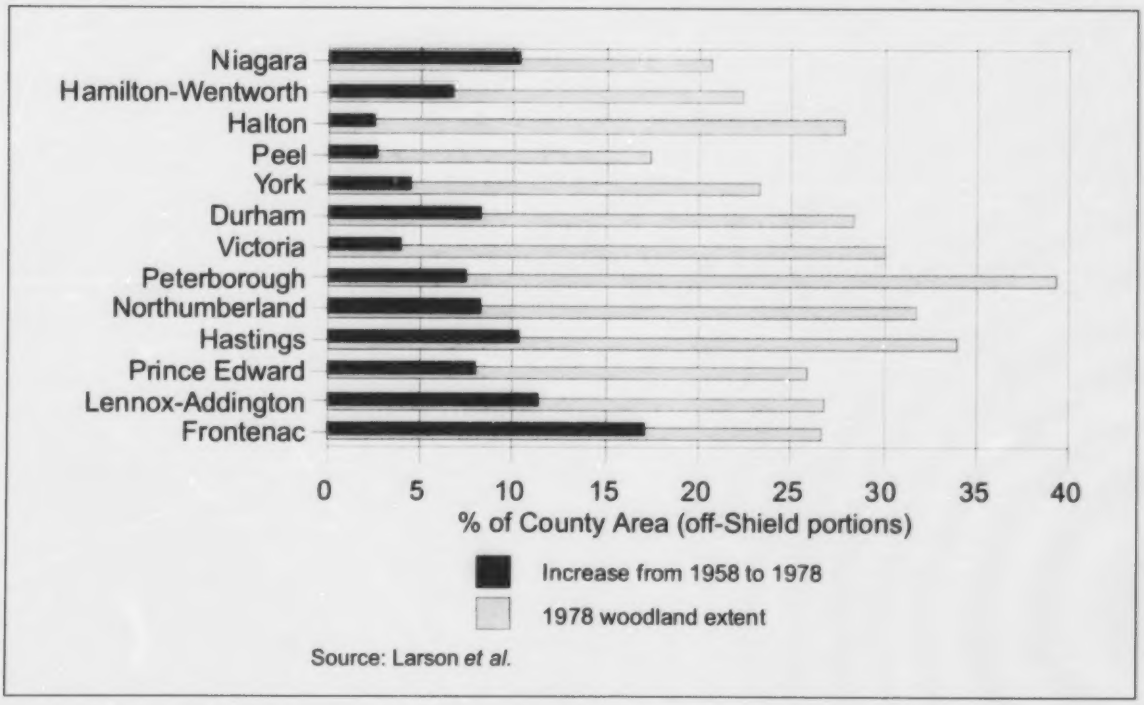
- Trends since 1978 are less clear, since it is difficult to compare recent satellite-based estimates of forest extent with earlier ground-based data. Larson *et al.* (1999) suggest a general trend of woodland increase, with exceptions in some areas, coupled with ageneral trend of decreasing wetland-scrubland, again with exceptions. However, both trends should be treated with caution.

The general pattern of historic forest loss across southern Ontario applies within the sections of the Lake Ontario watershed south of the Shield as well. In some parts of the watershed, however, the regeneration of woodlands has resulted in a greater extent of present forest cover. As shown in Figure 5, all Lake Ontario watershed counties from Durham eastwards exceed the southern Ontario average of 25.5% for woodland and scrubland cover, as does Halton in the west (refer to Figure 1 for full names of counties). More detailed township-level data reveal that woodland losses have generally been greatest near the Lake Ontario shore in the western part of the watershed, especially in Niagara and Peel.

Regeneration of forest and scrubland (from 1958 to 1978) has been lowest in urban and near-urban areas, and much greater in counties with less urban and/or agricultural pressure.

While the available data are not provided on an entire watershed basis, it appears likely that the only Lake Ontario counties that would meet the 30 percent forest cover guideline south of the Shield are Victoria, Peterborough, Northumberland, and Hastings. All of the watershed area on the Shield would substantially exceed that guideline.

Figure 5. Woodland extent and changes in Lake Ontario watershed counties (moving west to east)*



* No data are available for Toronto and Haliburton counties

The difficulty in providing reliable recent estimates of forest extent is shown by comparing estimates from two 1990s sources: the Ontario Hydro forest cover database, derived from satellite imagery (provided by the Natural Heritage Information Centre), and habitat estimates derived from early 1990s provincial Landsat imagery by the Ontario Ministry of Natural Resources (quoted in Couturier 1999). Table 2 provides a comparison of recent percent forest cover estimates for counties completely or almost completely within the watershed.

Table 2: Comparison of recent percent forest cover estimates

	Niagara	Hamilton - Wenworth	Halton	Peel	Toronto	Northumberland	Prince Edward
Hydro	14.3	11.5	13.9	12.1	2.9	22.9	17.9
OMNR	18.9	15.4	21.9	13.6	3.9	30.9	23.5

It is notable that all of these estimates are significantly lower than the 1978 figures provided in Figure 5. However, it is much more likely that these differences reflect different sampling and formatting methodologies rather than real trends. As noted by Larson *et al.* (1999), a consistent, standardized monitoring system to document trends in southern Ontario woodlands is urgently needed.

The Larson *et al.* (1999) study identifies a series of exceptional "heritage woodlands" across southern Ontario. Sites that fall within the Lake Ontario watershed are shown on Figure 6. These heritage woodlands display old-growth characteristics, a high number of woodland-conservative and rare species, and other features which set them apart as particularly good examples of remnant forest.

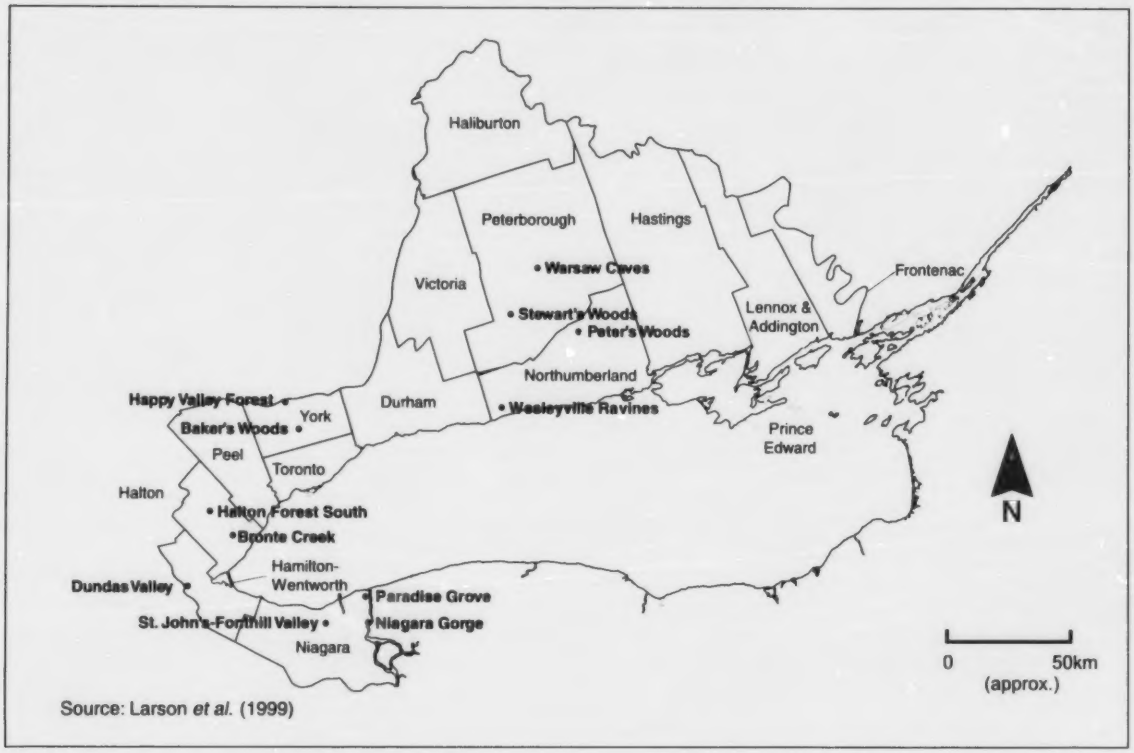
Forest cover has been fragmented in many parts of the watershed to levels that do not support the full range of native wildlife, and fragmentation is continuing.

As forest cover has been removed across southern Ontario, the remaining patches of woodland become smaller and more isolated. The effects of this fragmentation on forest wildlife, particularly birds, has been documented in a number of recent studies (e.g., Bender *et al.* 1998; Environment Canada *et al.* 1998b; Larson *et al.* 1999). Within fragmented habitats, the number of bird and mammal species requiring interior forest conditions declines, while the number of edge species increases. As well, there are longer-term concerns about the effects of genetic isolation associated with fragmentation.

One of the measures of fragmentation is the percentage of forest cover within a watershed or other study area that is more than 100 metres or 200 metres from the nearest forest edge. At a broad scale (such as the county level), the amount of forest over 200 metres from the edge is the most important factor in determining the richness of interior bird species (Environment Canada *et al.* 1998b). Rehabilitation guidelines established for AOCs include a guideline of 10 percent of each watershed with 100 metre forest interior, and five percent with 200 metre forest interior.

All of the sections of the Lake Ontario watershed on the Canadian Shield would exceed those guidelines. South of the Shield, however, at the county level no areas come even close (Table 3).

Figure 6. Heritage woodlands in the Lake Ontario watershed



Source: Larson *et al.* (1999)

Table 3: Forest interior at the county level*

	Percent of Forest 100 m from Edge	Percent of Forest 200 m from Edge
Area of Concern Rehabilitation Guideline	**>10.0**	**>5.0**
Niagara	2.1	0.4
Hamilton-Wentworth	1.9	0.5
Halton	3.2	1.1
Peel	1.3	0.1
York	0.2	0.0
Toronto	0.1	0.0
Durham	2.4	0.7
Victoria (south)	5.0	1.7
Peterborough (south)	1.2	0.4
Northumberland	4.6	1.6
Hastings (south of Shield)	0.8	0.2
Prince Edward	3.4	1.1
Lennox & Add. (south)	1.3	0.3
Frontenac (south of Shield)	0.3	0.1

Data Source: Ontario Hydro Forest Cover Mapping, provided by Natural Heritage Information Centre, 2000
* No data are available for Haliburton county

Several studies associated with AOCs have examined watershed areas in more detail, including assessments of forest interior conditions. These studies also include data on the largest natural area patch size, another useful measure of the distribution of interior forests. As shown in Table 4, only a few of the forest interior guidelines are met by current conditions within these watersheds, even though two of them contain relatively large single forest patches. In general, they confirm the county-level data at a more local scale, emphasizing the serious shortfalls in forest interior habitats across the agricultural sections of the Lake Ontario basin.

Table 4: Forest interior conditions within selected Area of Concern watersheds

	Percent Natural Area Cover	Largest Forest Patch (ha)	Percent of Forest 100 m from Edge	Percent of Forest 200 m from Edge
Area of Concern Rehabilitation Guideline	**>30.0**	**200.0**	**>10.0**	**>5.0**
Niagara Area of Concern	14.7	**786.6**	1.1	0.1
Humber River	17.9	**444.3**	2.2	0.4
Wilton Creek	26.5	52.0	**11.5**	3.1
South Sidney	23.5	20.6	5.2	0.5

Data sources: Holland-Hibbert 1996; Lower Trent Conservation 1997; Toronto and Region Conservation Authority 1998a

Information on trends in forest fragmentation over time is very limited. However, the Niagara Escarpment Monitoring Program (Geomatics International 1997) has provided one example for the 1976 to 1995 period in the southern section of the Niagara Escarpment Planning Area. Their results point out the pervasiveness of the fragmentation problem – even though the total forest area increased slightly (by about two percent) over that period, the number of forest patches increased more rapidly, and the average forest patch size declined significantly.

Also, during this period, the effects on forest interior habitats were striking. The total amount of 100 metre interior forest dropped from 13 454 hectares to 10 242 hectares (a drop of 24 percent); the amount of 200 metre interior forest dropped even more sharply – from 7 641 hectares to 4 357 hectares (a drop of 43 percent).

Despite the fact that the amount of forest in the landscape is increasing, one of the most pressing habitat issues within the watershed is the pattern of increasing forest fragmentation which is likely to be present in the entire Lake Ontario watershed south of the Canadian Shield.

Wetlands

Wetland loss has been recognized as a significant issue in southern Ontario for the past two decades, and a provincial wetlands policy and evaluation process have become widely-accepted parts of the land use planning process. Wetland rehabilitation, particularly focused on marshlands, has been a priority for government agencies and conservation organizations. The Great Lakes Wetlands Conservation Action Plan (GLWCAP) is a cooperative program that involves federal and provincial governments (such as Environment Canada and the Ontario Ministry of Natural Resources) and non-government organizations (such as the Nature Conservancy of Canada, Federation of Ontario Naturalists and Ducks Unlimited Canada) in efforts to establish a comprehensive wetlands conservation program for Great Lakes wetlands. The Action Plan's goal is to create, reclaim, rehabilitate and protect wetland habitat in the lower Great Lakes basin.

Historic wetland losses have been significant within the Lake Ontario watershed, especially in the western and southern sections.

The most comprehensive study on the historic extent and loss of wetlands in southern Ontario (Snell 1987) summarized the regional wetland situation in five groupings within and overlapping the Lake Ontario watershed:

- The Niagara and eastern Lake Erie area, which includes Niagara and Hamilton-Wentworth, dropped from 29.5 percent pre-settlement wetland to 7.0 percent in 1982, largely as a result of intensive agriculture.

- The West and western Lake Ontario area, which includes Halton, Peel, and Toronto as well as counties to the west, dropped from 11.3 percent pre-settlement wetland to 3.9 percent in 1982, which was related to agriculture and urban development.

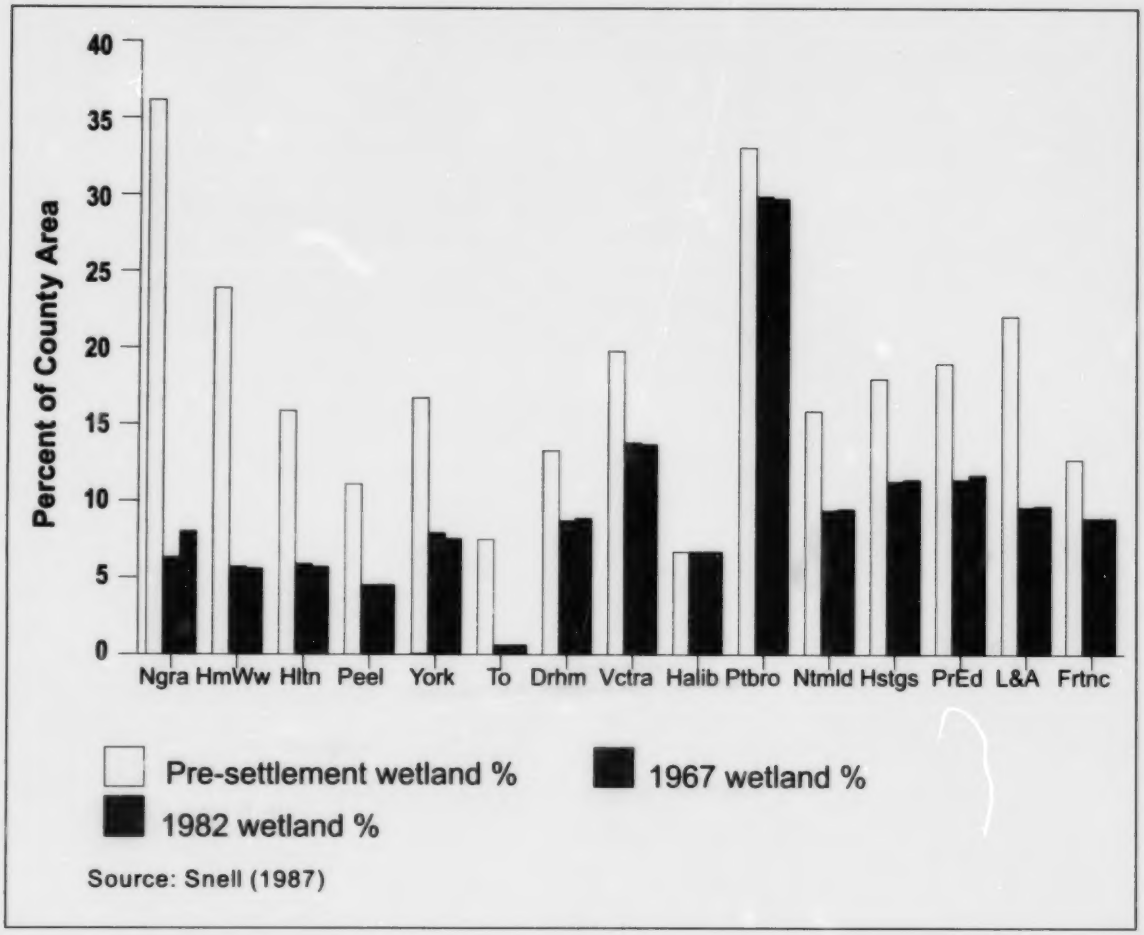
- The West Central area, including York, Northumberland and Durham as well as several counties to the north, dropped from 15.9 percent pre-settlement wetland to 8.7 percent in 1982, again related to intensive agriculture and local urbanization.

- The East Central area, stretching from Victoria County to Frontenac, dropped from 24.6 percent pre-settlement wetland to 12.6 percent in 1982, as a result of low intensity agriculture and localized cottage development.

- The Peterborough County area dropped from 28.5 percent pre-settlement wetland to 23.7 percent in 1982.

A more detailed county-level breakdown of wetlands as a percentage of total land area at three time periods is provided in Figure 7. Township-level data on wetlands remaining in 1982 is provided in Figure 8.

Figure 7. Historic wetland extent from pre-settlement to 1982



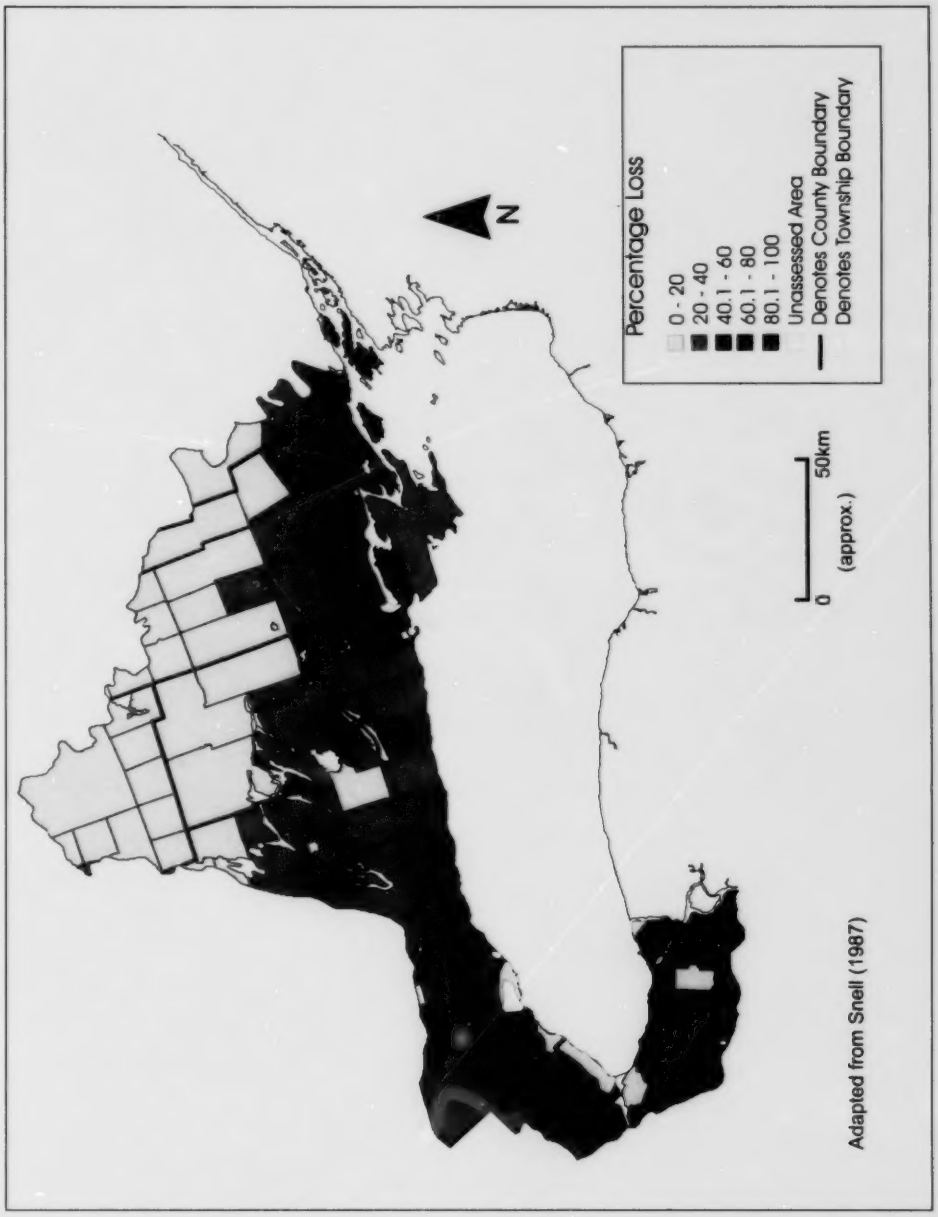
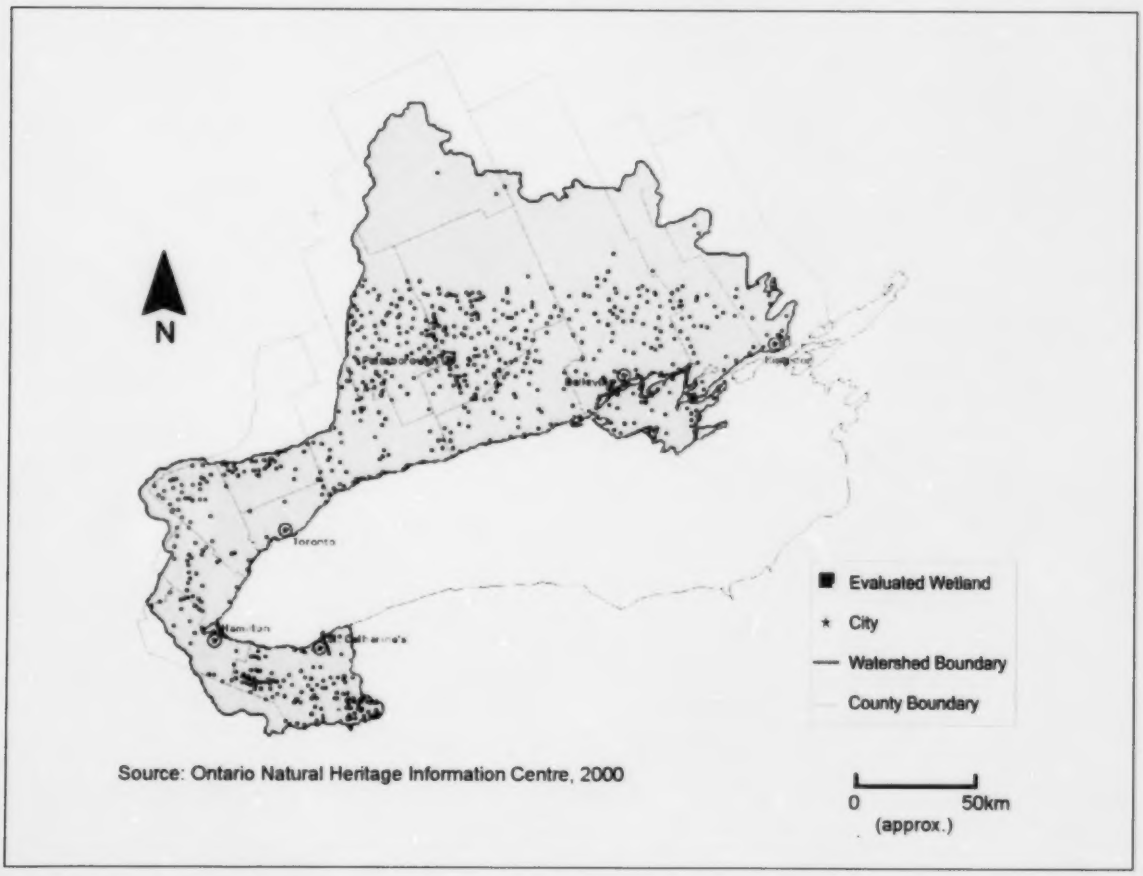


Figure 8. Conversion of original wetland area in Lake Ontario watershed townships

Significant wetland concentrations are associated with the Peterborough drumlin field, the edge of the Canadian Shield, and the Niagara Escarpment.

Wetlands in southern Ontario are evaluated with a standardized system by the Ontario Ministry of Natural Resources (OMNR). As shown in Figure 9, evaluated wetlands are not distributed evenly across the Lake Ontario watershed, but are especially common in the Peterborough drumlin field, along the southern edge of the Shield, and along the Niagara Escarpment. As well, wetlands are relatively frequent along the Oak Ridges Moraine and Dummer Moraine, and on the Haldimand clay plain within the Niagara River drainage basin. Wetlands are scarce on the Peel plain and the other intensively used agricultural and urban areas south of the Oak Ridges Moraine. The scarcity of evaluated wetlands on most of the Shield area reflects a lack of evaluation effort, rather than a lack of wetland occurrences. A total of 754 wetlands within the Lake Ontario watershed (including the Niagara River watershed) have been evaluated as provincially significant from about 1983 to the present. Table 5 summarizes the extent of wetlands evaluated as provincially significant within the Lake Ontario watershed.

Figure 9. Evaluated wetlands in the Lake Ontario watershed



Source: Ontario Natural Heritage Information Centre, 2000

Table 5: Provincially Significant Wetlands (PSWs) in the Lake Ontario watershed

County	Number	Total Area of PSW (ha)
Niagara	140	5 431
Hamilton-Wentworth	18	3 639
Halton	27	2 257
Peel	39	2 866
York	36	771
Toronto	8	225
Durham	56	7 866
Victoria	88	26 235
Haliburton	3	610
Peterborough	132	25 075
Northumberland	49	7 249
Hastings	83	13 389
Prince Edward	30	8 796
Lennox-Addington	30	5 853
Frontenac	15	8 364

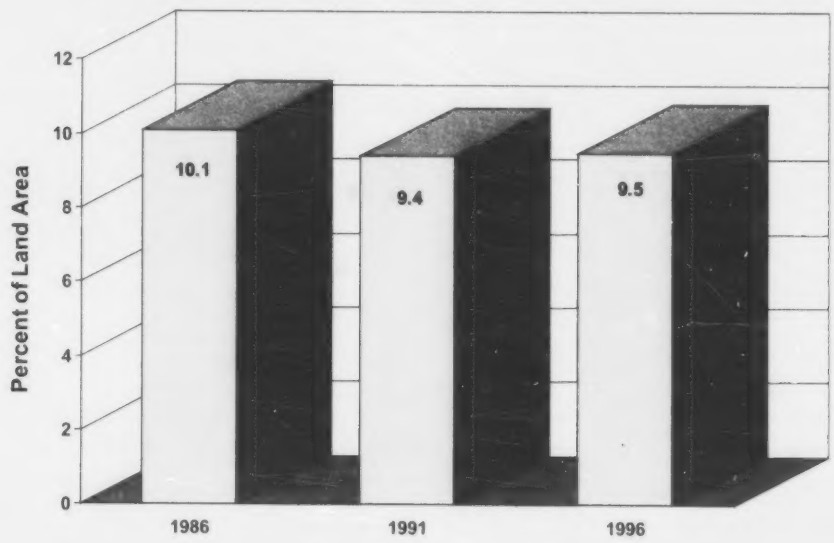
Data Source: Ontario Natural Heritage Information Centre, 2000

Grassland Habitats

The area of grassland habitats has stabilized but grassland birds are declining in most parts of the watershed.

While grassland habitats were of limited extent in pre-settlement Ontario, they expanded significantly during the early agricultural period. In recent decades, the amount of grassland (including pastures, early successional and prairie/alvar remnants) has declined within the Lake Ontario watershed as a result of changing farm practices and the regeneration of some farmlands into woodland. In the southwestern section of the basin, grassland now occupies between three and six percent of each county; most other counties range from seven to 12 percent, but Victoria County has over 28 percent of its area currently in grassland.

Figure 10. Grassland as a percent of land area in the Lake Ontario watershed



Source: Ontario Ministry of Agriculture, Food and Rural Affairs (1990, 1996)

As shown in Figure 10, the decline in grassland acreage appears to have stabilized in the 1990s. This is the result of increased grassland in about half of the watershed counties during the first half of the decade. The other counties, particularly Peterborough and Northumberland, continue to lose grassland at a relatively rapid rate.

Both across North America and in Canada, grassland birds, such as the loggerhead shrike and Henslow's sparrow, have experienced steeper, more consistent, and more widespread population declines over the past quarter century than any other group of birds (Vickery *et al.* 1996; Dunn and Downes 1998). Besides loss of habitat, the effects of habitat fragmentation may also be an important factor for many grassland species (Friesen 1994).

Priority Bird Habitats

The highest priority habitats for assemblages of forest birds occur in the northern sections of the Lake Ontario watershed.

A methodology for identifying priorities within the landscape for assemblages of breeding birds, rather than individual species, has recently been developed by Bird Studies Canada (Couturier and Bradstreet 1999). This approach uses three distinct components to establish bird conservation priorities at the municipal level:

- **Jurisdictional Responsibility** is based on breeding distribution information and reflects the importance of a particular region to each bird species relative to its breeding distribution.

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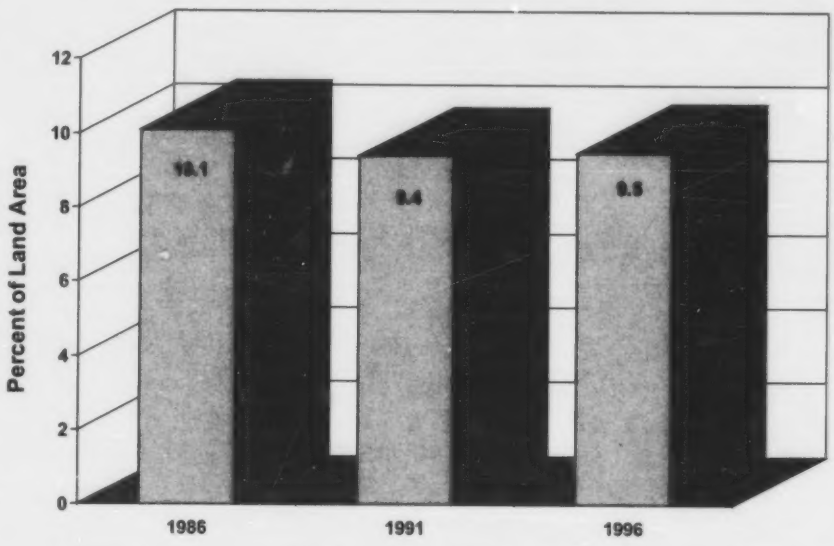

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- **Jurisdictional Responsibility** is based on breeding distribution information and reflects the importance of a particular region to each bird species relative to its breeding distribution.

- **Preservation Responsibility** uses information on each species' abundance, population trend, and sensitivity to identify the most vulnerable species at the provincial level.

- **Area Sensitivity** relates to the habitat-area requirements of a species.

Each breeding species is assigned a score for each of these three components. Species are highlighted as a priority if they score highly on one or more components, and a composite score is used to rank species by conservation priority at the local level. A list of priority bird species for the Lake Ontario watershed, derived from these composite scores, is shown in Table 6. All four levels of priority shown within the table are considered significant within the watershed context; level one priority birds represent birds of the highest priority (most at risk) while level four priority birds represent those of the lowest risk.

This planning tool can be taken one step further to develop species richness maps, which depict patterns of concentration of priority bird species, and thus can be used to broadly identify zones of highest conservation value. A species richness map for the Lake Ontario watershed has been provided by Bird Studies Canada (BSC), and is shown as Figure 11 (page 27).

Table 6: List of priority birds in the Lake Ontario watershed

FOREST	MARSH	OPEN COUNTRY
LEVEL ONE	LEVEL ONE	LEVEL ONE
Species Name	Species Name	Species Name
Acadian Flycatcher++	American Bittern	Barn Owl++
Bald Eagle++	American Coot	Brown Thrasher
Barred Owl	Black Tern*	Clay-colored Sparrow
Black-throated Green Warbler	Black-crowned Night-Heron	Eastern Bluebird
Blackburnian Warbler	King Rail++	Henslow's Sparrow++
Blue-winged Warbler	Least Bittern*	Loggerhead Shrike++
Broad-winged Hawk	Pied-billed Grebe	Northern Bobwhite++
Brown Creeper	Sedge Wren	Northern Mockingbird
Canada Warbler	Short-eared Owl*	Savannah Sparrow
Cerulean Warbler*	Sora	
Chestnut-sided Warbler	Virginia Rail	
Golden-winged Warbler	Yellow Rail*	
Hooded Warbler++		
Long-eared Owl		
Louisiana Waterthrush*		
Magnolia Warbler		
Nashville Warbler		
Northern Saw-whet Owl		
Prairie Warbler		
Prothonotary Warbler++		
Red-headed Woodpecker*		
Red-shouldered Hawk*		
White-throated Sparrow		
Yellow-bellied Sapsucker		
Yellow-breasted Chat*		

FOREST	MARSH	OPEN COUNTRY
LEVEL TWO	**LEVEL TWO**	**LEVEL TWO**
Species Name	**Species Name**	**Species Name**
American Redstart	American Black Duck	American Kestrel
Black-and-white Warbler	Blue-winged Teal	Bank Swallow
Black-billed Cuckoo	Common Loon	Bobolink
Black-throated Blue Warbler	Common Snipe	Common Nighthawk
Chuck-will's-widow	Marsh Wren	Eastern Meadowlark
Eastern Towhee	Osprey	Upland Sandpiper
Mourning Warbler	Purple Martin	Vesper Sparrow
Northern Goshawk	Swamp Sparrow	Western Meadowlark
Northern Waterthrush		
Olive-sided Flycatcher		
Pileated Woodpecker		
Purple Finch		
Red-bellied Woodpecker		
Ruby-throated Hummingbird		
Scarlet Tanager		
Sharp-shinned Hawk		
Veery		
Whip-poor-will		
White-eyed Vireo		
Yellow-bellied Flycatcher		
LEVEL THREE	**LEVEL THREE**	**LEVEL THREE**
Species Name	**Species Name**	**Species Name**
Alder Flycatcher	Common Moorhen	American Goldfinch
American Woodcock	Gadwall	Barn Swallow
Carolina Wren	Lesser Scaup	Cliff Swallow
Cooper's Hawk	Ring-necked Duck	Eastern Kingbird
Eastern Phoebe		Field Sparrow
Evening Grosbeak		Grasshopper Sparrow
Golden-crowned Kinglet		Horned Lark
Hermit Thrush		Le Conte's Sparrow
Hooded Merganser		Northern Rough-winged Swallow
Least Flycatcher		Spotted Sandpiper
Pine Warbler		

FOREST	MARSH	OPEN COUNTRY
LEVEL THREE (cont.)	**LEVEL THREE (cont.)**	**LEVEL THREE (cont.)**
Species Name	**Species Name**	**Species Name**
Red-breasted Nuthatch		
Ruffed Grouse		
Solitary Vireo		
LEVEL FOUR	**LEVEL FOUR**	**LEVEL FOUR**
Species Name	**Species Name**	**Species Name**
Bay-breasted Warbler	American Wigeon	
Black-capped Chickadee	Canvasback	
Blue-gray Gnatcatcher	Common Tern	
Cape May Warbler	Green Heron	
Chimney Swift	Northern Harrier	
Dark-eyed Junco	Northern Pintail	
Gray Catbird		
Great Crested Flycatcher		
Hairy Woodpecker		
Orchard Oriole		
Ovenbird		
Red Crossbill		
Ruby-crowned Kinglet		
Swainson's Thrush		
Wild Turkey		
Wood Duck		
Wood Thrush		
Yellow-throated Vireo		

Source: Bird Studies Canada, 2000

++ Designated as endangered or threatened at federal or provincial level

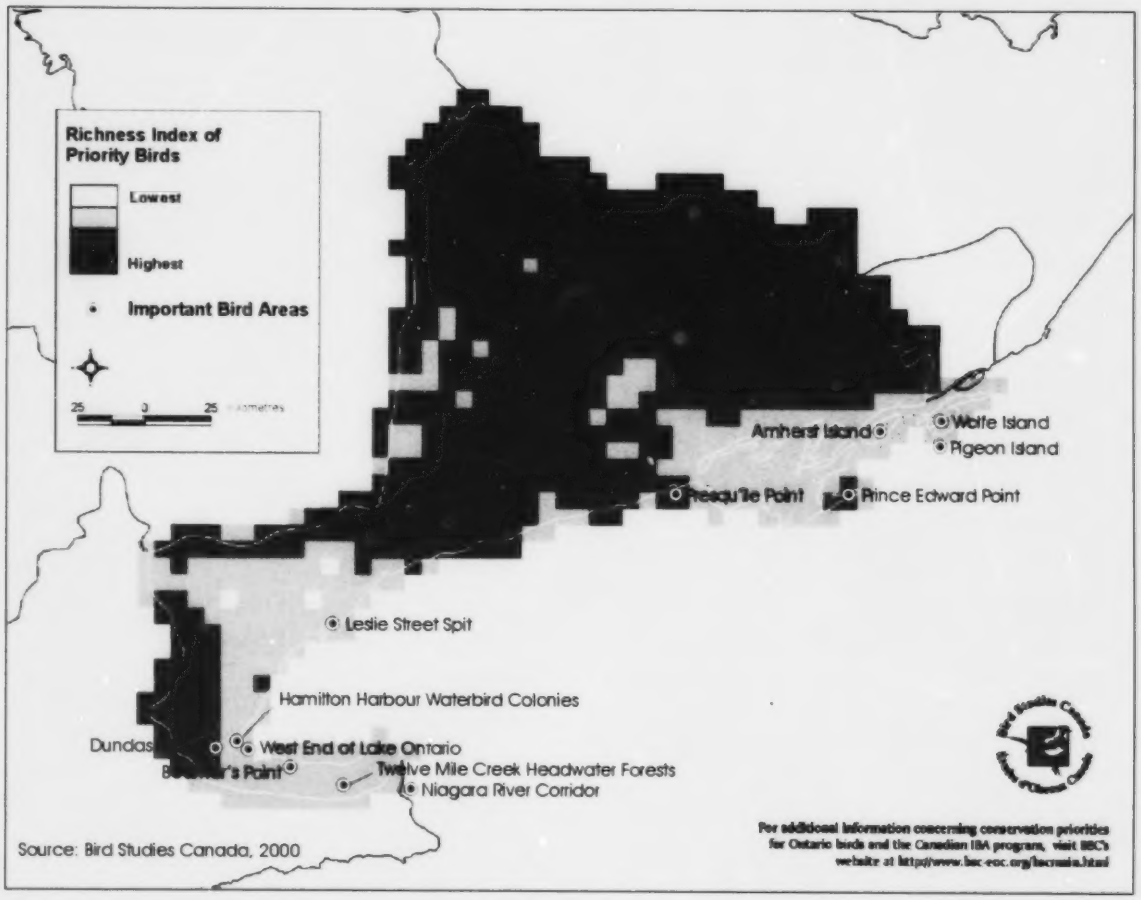
* Designated as vulnerable at federal or provincial level

Designated Important Bird Areas are primarily located along the Lake Ontario coast.

A second program which highlights key habitats for bird species is the Important Bird Areas (IBA) Program, an international conservation program that uses standard criteria to identify critical bird habitats of global, continental, or national significance. This Program identifies sites which act as concentration points, often during migration, for a significant proportion of a species' population. In Ontario, this includes sites such as Presqu'ile Point which act as staging areas for shorebirds and songbirds.

The Ontario IBA Program, delivered by BSC, the Canadian Nature Federation, and the Federation of Ontario Naturalists (FON), is in its early stages, but conservation planning is underway for a number of IBAs. Designated IBAs within the Lake Ontario basin are shown on Figure 11; additional sites may be identified in future.

Figure 11. Patterns of species richness for priority birds and Important Bird Areas



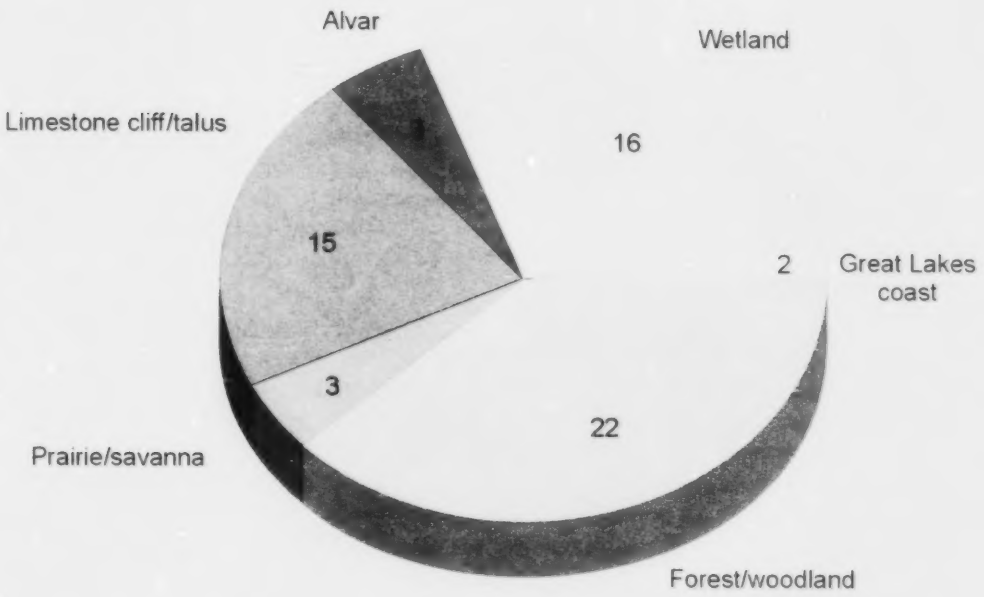
Natural Communities at Risk

Rare vegetation communities occur in clusters along the Niagara Escarpment and in the Northumberland-Hastings area.

Within the past several years, the development of a standardized ecological classification for natural communities in southern Ontario (Lee *et al.* 1998) has provided a stronger basis for identifying communities at risk. Community information from field inventories is being gradually added to the database at the Natural Heritage Information Centre (NHIC). While this information base is not complete, at least some general patterns can be observed.

A total of 61 rare vegetation community types has been identified within the Lake Ontario watershed, based on an analysis provided by the NHIC. As shown in Figure 12, these rare communities are largely clustered in forest and woodland, wetland, and limestone cliff and talus habitats.

Figure 12. Habitat associations of 61 rare vegetation community types



Source: Ontario Natural Heritage Information Centre, 2000

It is important to note that some of these community types have always been rare in southern Ontario. Limestone cliff and talus communities, for example, are primarily restricted to the Niagara Escarpment face, and have never had a broad distribution. Alvar habitats, which occur in the Lake Ontario watershed mostly on the Napanee limestone plain, have always been sparsely distributed within the Great Lakes region (Reschke *et al.* 1999). Prairie and savanna habitats once covered from 800 to 2 000 square kilometres of southern Ontario, including extensive areas around Rice Lake and smaller sites in the Toronto and Hamilton areas (Rodger 1998). Now only tiny remnants remain within the Lake Ontario basin. Some wetland types, such as Leatherleaf shrub bog and Pin Oak mineral deciduous swamp, may be common elsewhere in their range, but are rare in the context of southern Ontario.

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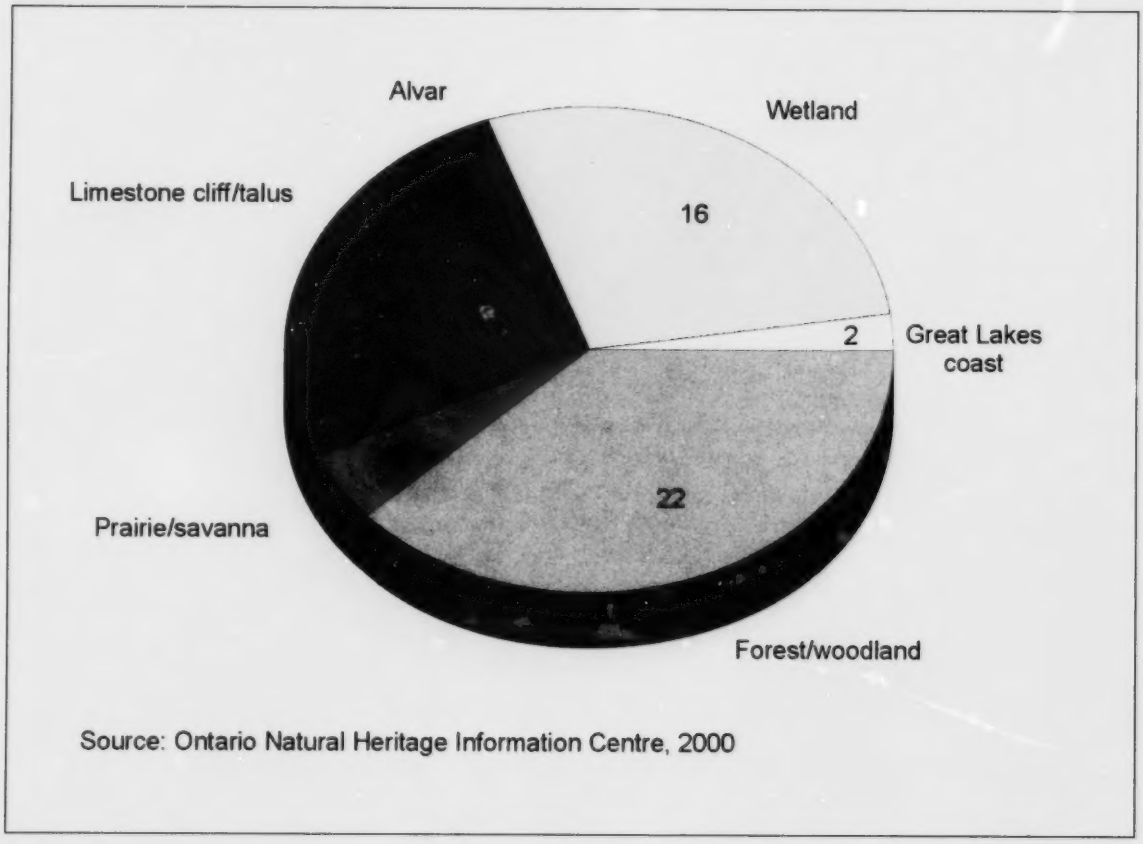

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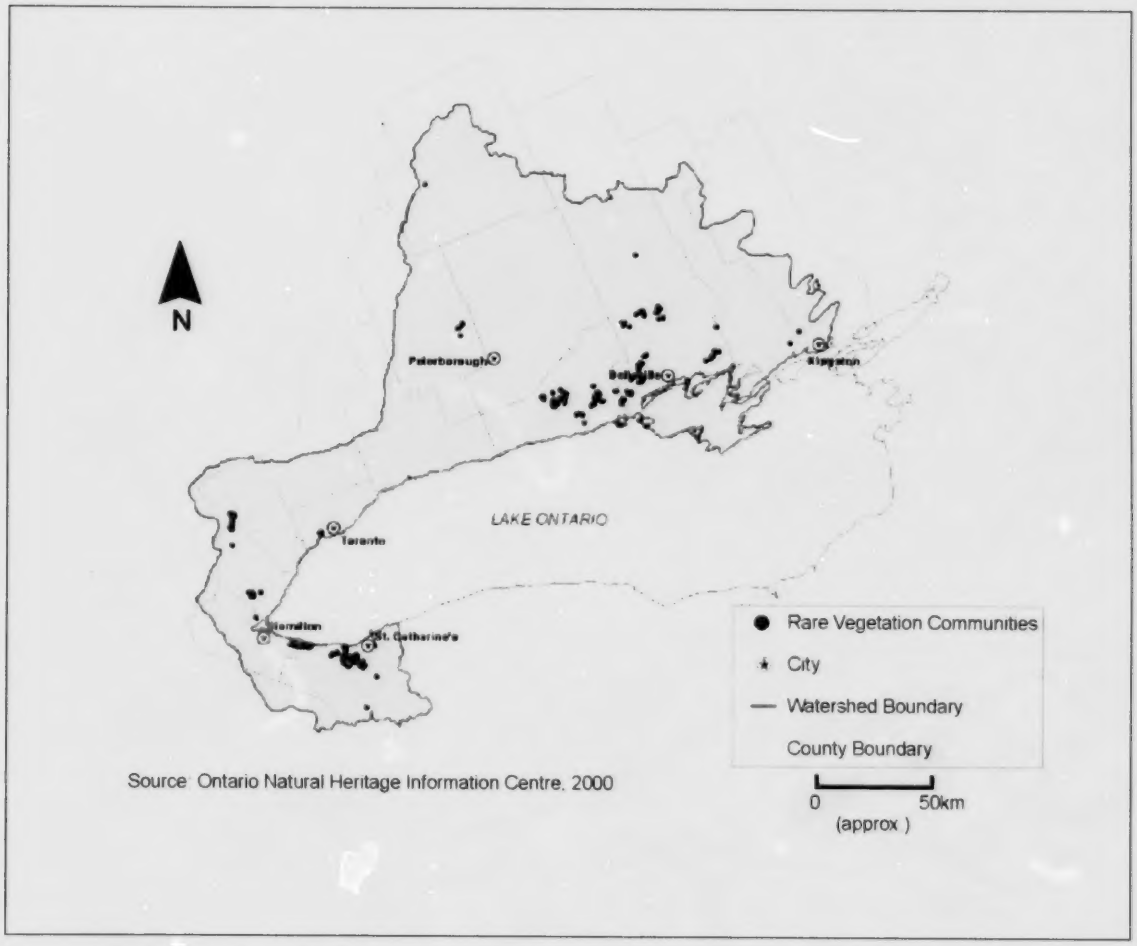
Other communities now listed as rare, particularly within the forest/woodlands and wetlands categories, were much more common at the time of European settlement. In many of the remaining sites, the quality of the natural features has been compromised by repeated logging or other disturbances.

The distribution of rare communities, as shown in Figure 13, has a strong orientation to the Niagara Escarpment and to the Northumberland-Hastings area. As additional sites are added to the NHIC database, this pattern may change.

Figure 13. Occurrences of rare vegetation communities in the Lake Ontario watershed



Species at Risk

Rare species are distributed broadly across the Lake Ontario watershed, with a particular concentration in the Niagara Region.

A comprehensive databank of species at risk is maintained by the NHIC, which classes individual species as S1 (critically imperiled * fewer than five occurrences in the province), S2 (imperiled * six to 20 occurrences) or S3 (vulnerable to extinction * 21 to 100 occurrences). Table 7 shows the distribution of rare species known occurrences across the Lake Ontario watershed.

Table 7: Distribution of rare species occurrences in the Lake Ontario watershed

County	S1	S2	S3	Total
Niagara	33	68	93	194
Hamilton-Wentworth	9	21	40	70
Halton	8	38	55	101
Peel	2	5	20	27
York	1	0	25	26
Toronto	18	29	40	87
Durham	0	0	24	24
Victoria	0	3	14	17
Haliburton	1	1	18	20
Peterborough	0	10	57	67
Northumberland	5	7	5	17
Hastings	8	18	31	57
Prince Edward	1	15	13	29
Lennox & Addington	2	31	12	45
Frontenac	1	6	19	26

Data Source: Ontario Natural Heritage Information Centre, 2000

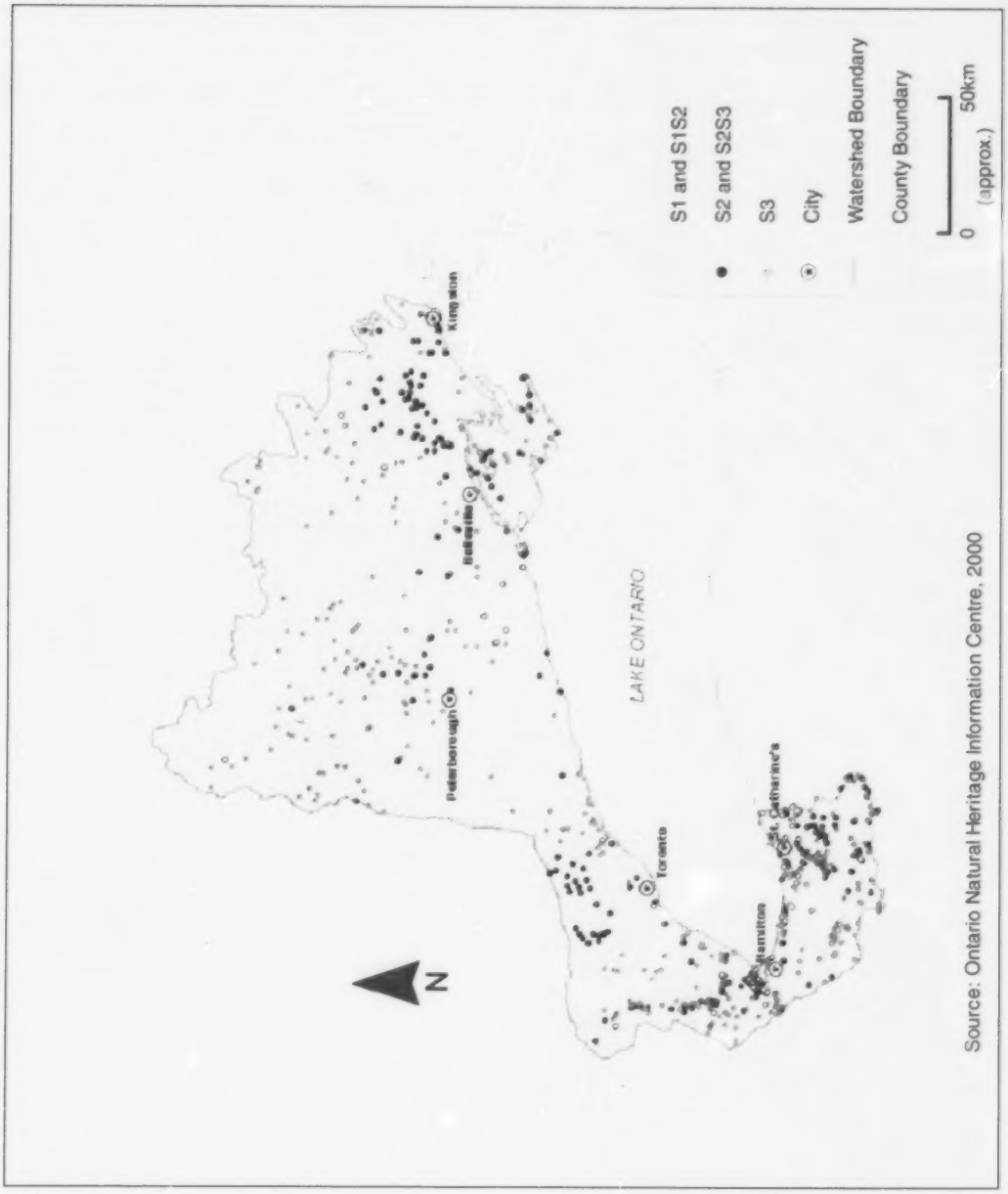
Many of these rare species are associated with rare community types, especially the limestone cliff and talus habitats along the Niagara Escarpment. A substantial number of the species at risk are organisms pushing against the northern limits of their range. These species take advantage of the climatic moderation provided by the Great Lakes, especially in areas such as Niagara, but are usually present with low population levels. As the northernmost representatives of their species, they may have genetic adaptations to meet the challenge of Canadian winters.

Populations of some species or groups of species are clearly at risk because of habitat deterioration or loss. For example, grassland birds including the endangered loggerhead shrike and Henslow's sparrow appear to be declining rapidly in large measure because of the loss of pasturelands and other grassland habitats. Another group of bird species with rapidly declining populations are the neotropical migrants (forest songbirds) which breed strictly in forest interiors, a habitat type which has undergone severe losses within this region.

Species and communities that are rare or threatened at the regional or local level also need to be considered by conservation authorities and municipalities in their planning and rehabilitation programs. For example, amphibian species such as wood frog that are relatively common in rural areas have become very rare within the urban parts of the watershed, and need special attention to maintain the fullest possible spectrum of biodiversity there.

Figure 14 shows the distribution of provincially rare species across the watershed.

Figure 14. Distribution of provincially rare species in the Lake Ontario watershed



2.4 Current Stressors and Impacts

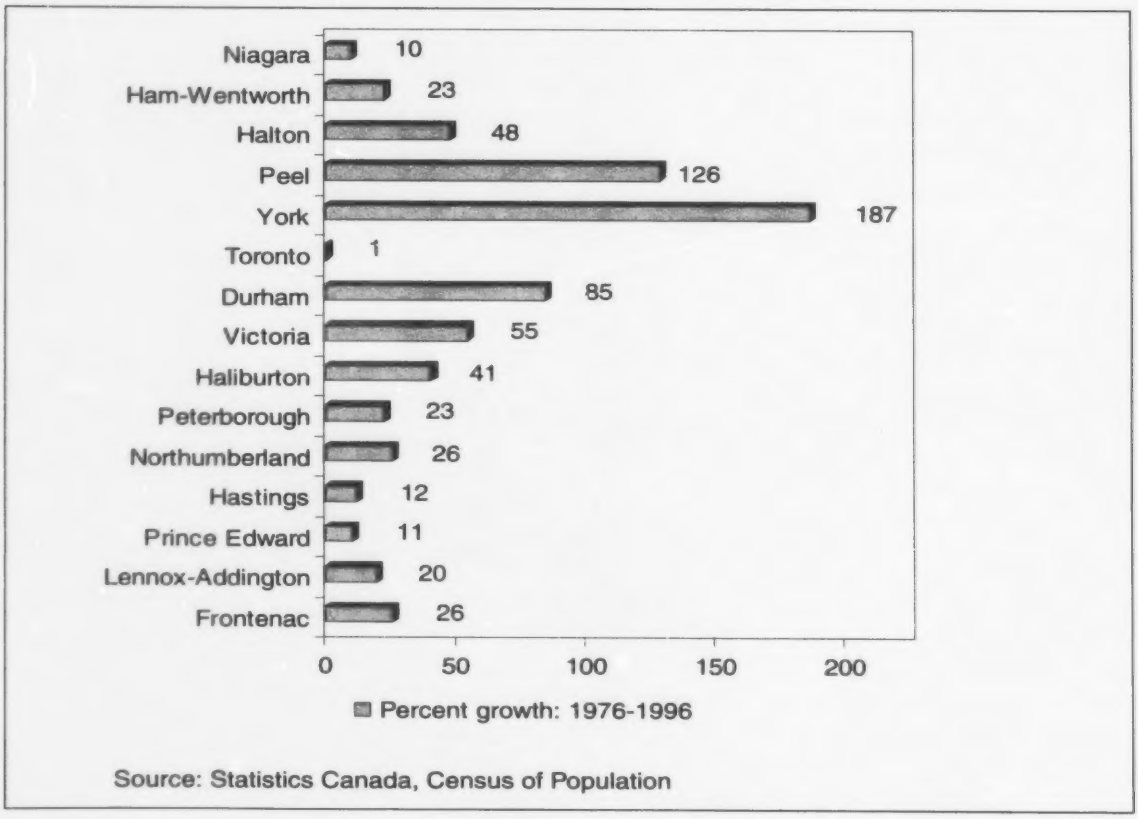
Human Population Growth

Most population growth has been on the urban fringe.

Many of the ecological stressors within the Lake Ontario watershed are directly related to the rapid growth of human populations. By the mid-1990s, over 5.4 million people lived on the Canadian side of the Lake Ontario basin (Statistics Canada 1994). Between 1976 and 1996, the population within the counties and regions of the basin grew by 40 percent, a growth rate of 2.0 percent/year (Statistics Canada, Census of Population; Figure 15). It is notable that the Canadian population within the Lake Ontario basin grew ten times faster in this period than the U.S. Lake Ontario basin population (Thorp *et al.* 1996).

However, this growth was not evenly spread across the Lake Ontario watershed. As shown in Figure 15, the four regions centered around Toronto contributed most of the population growth, with growth rates much lower in more rural areas. (The moderately high growth rates in Victoria and Haliburton actually added few people since the base populations there were so small.)

Figure 15. Population growth in Lake Ontario counties: 1976 to 1996



Source: Statistics Canada, Census of Population

Data analysis provided by the OMNR looks at census units within the Lake Ontario watershed in five population categories sparse, sparse-rural, rural, semi-urban and urban. As shown in Table 8, these population categories have changed in quite different ways over the 15-year period from 1981 to 1996:

- The parts of the watershed with sparse populations have shrunk in both area and population, although they still make up 43 percent of the total watershed area.
- Urban populations have expanded at an even faster rate than the urban area, indicating that these sections of the watershed are becoming more dense.
- In contrast, the semi-urban category has grown faster in area than in population, highlighting the pervasive effects of low-density urban sprawl. The semi-urban class showed the fastest rates of change, by a considerable margin, in both area and population.
- As a percentage of the total population in the Lake Ontario basin, the sparse and sparse-rural classes have both declined, while the urban class has increased.

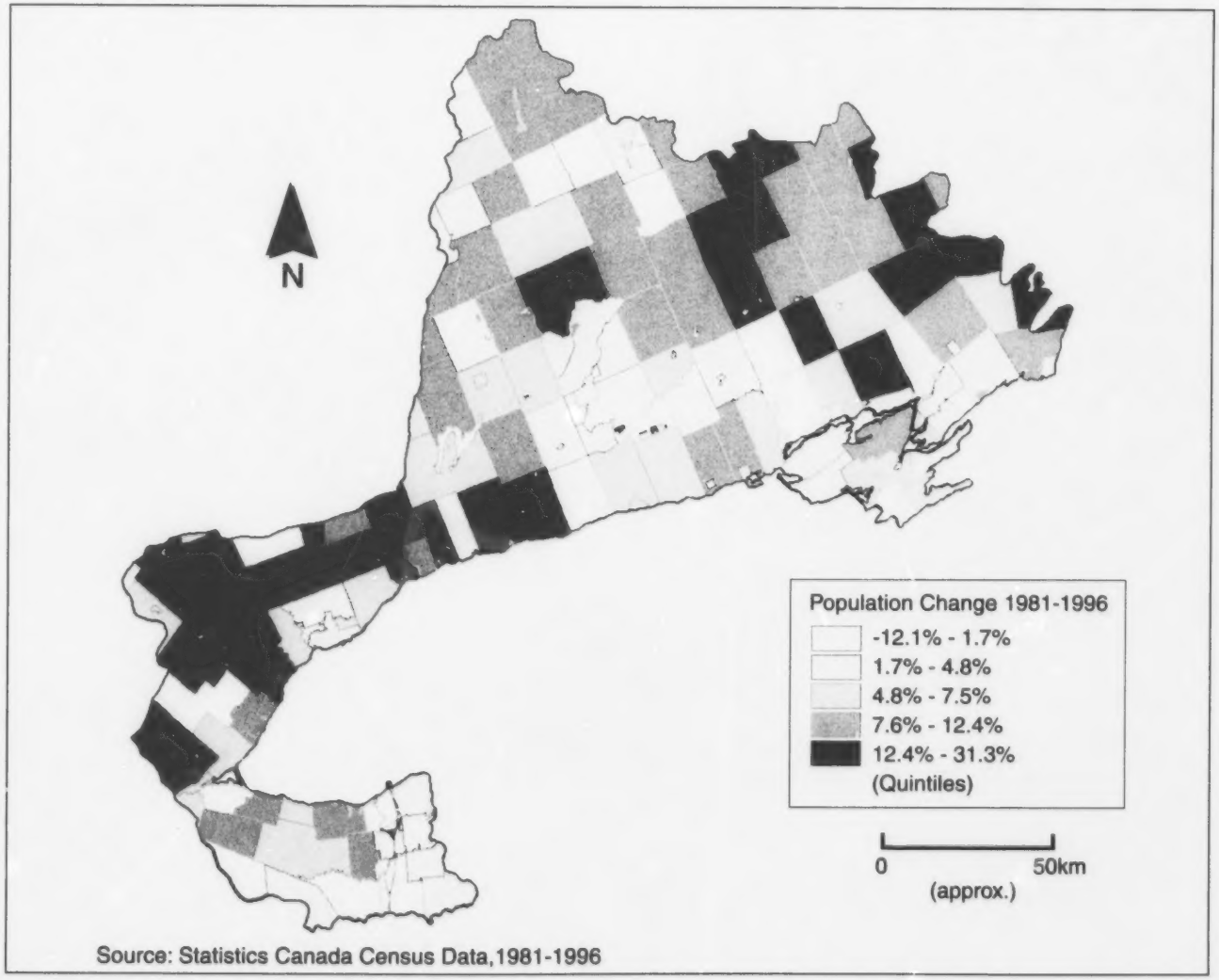
Table 8: Population distribution by population density class: 1981 to 1996

Year	Sparse *<10 pers/km²*		Sparse-Rural *10-25 pers/km²*		Rural *25-50 pers/km²*		Semi-Urban *50-100 pers/km²*		Urban *>100 pers/km²*		Total Population (000s)
	Pop. (000s)	% of Total	Pop. (000s)	% of Total	Pop. (000s)	% of Total	Pop. (000s)	% of Total	Pop. (000s)	% of Total	
1981	57.5	1.25	137.3	2.98	130.1	2.83	93.0	2.02	4182	90.92	4600
1986	58.2	1.18	135.6	2.75	134.0	2.72	103.9	2.11	4501	91.25	4933
1991	46.8	0.85	141.4	2.56	161.8	2.93	110.6	2.00	5063	91.66	5523
1996	49.6	0.83	134.0	2.26	157.6	2.65	130.2	2.19	5470	92.07	5942
Percent Pop. Change 1981-96	-13.77		-2.37		21.12		39.95		30.80		
Percent Area Change 1981-96	-15.80		-9.83		18.11		43.70		19.40		

Data sources: Statistics Canada data analyzed by Ontario Ministry of Natural Resources, 2000

Figure 16 maps the areas of population change over the 1981 to 1996 period, with the municipalities showing the greatest change in percentage terms clustered around the fringes of the Toronto urban area. Some of the rural areas in the eastern part of the watershed also show a high percentage change, but because of their small populations, this represents relatively few additional people.

Figure 16. Percentage population change in Lake Ontario watershed municipalities: 1981 to 1996



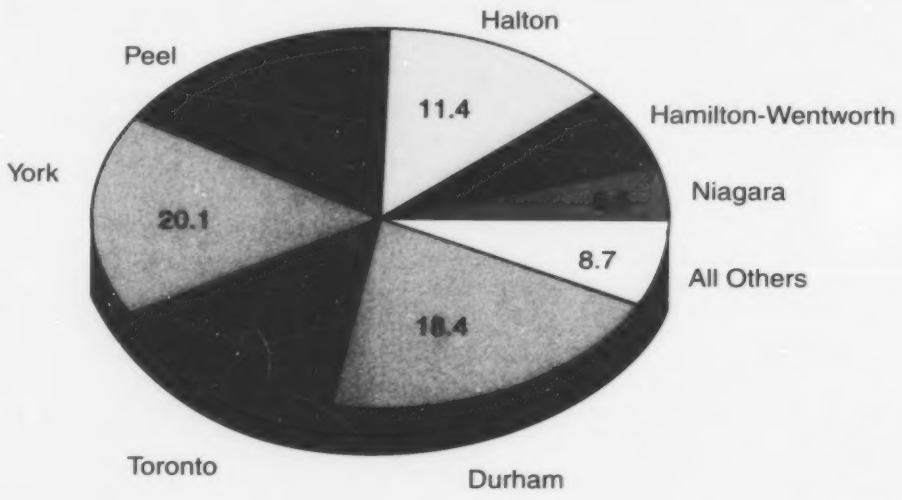
Most of the future population growth will be within the Greater Toronto Area and the Hamilton to Niagara area.

Population projections for the 25 years from 1996 to 2021 predict total growth within the fifteen counties and regions encompassing the Lake Ontario watershed of just over 2.3 million people (Ontario Ministry of Finance 1995). This predicted increase in population of 37 percent is significantly slower than population growth rates in the past, representing an annual rate of increase of 1.5 percent, as compared to 2.0 percent per year over the past two decades.

Similar to growth patterns in the past, the stresses created by this growth will not be felt evenly across the Lake Ontario basin (Figure 17). The three Greater Toronto Area regions of York, Durham and Peel will absorb more than half of the projected population growth, so that pressures on farmland and natural areas will be most intense within those areas. While Toronto will grow relatively slowly as a percentage of its existing population, it will still be home to a significant number of new people.

Urban expansion involves the conversion of existing agricultural and natural landscapes to a variety of urban uses. While the extent of this conversion depends on the types of landscapes and urban uses involved, a few studies have attempted to predict its scale. For example, a 1990 study of urban structure concepts for the Greater Toronto Area predicted an increase of 9 875 hectares in Halton Region's urban area by the year 2021, assuming a nodal growth pattern. This would bring approximately 2 000 hectares of forested area into the urban envelope, along with a large amount of high-quality farmland (Greater Toronto Area Urban Structure Concepts Study 1990).

Figure 17. Projected population growth to 2021. Share of new population * percent of total

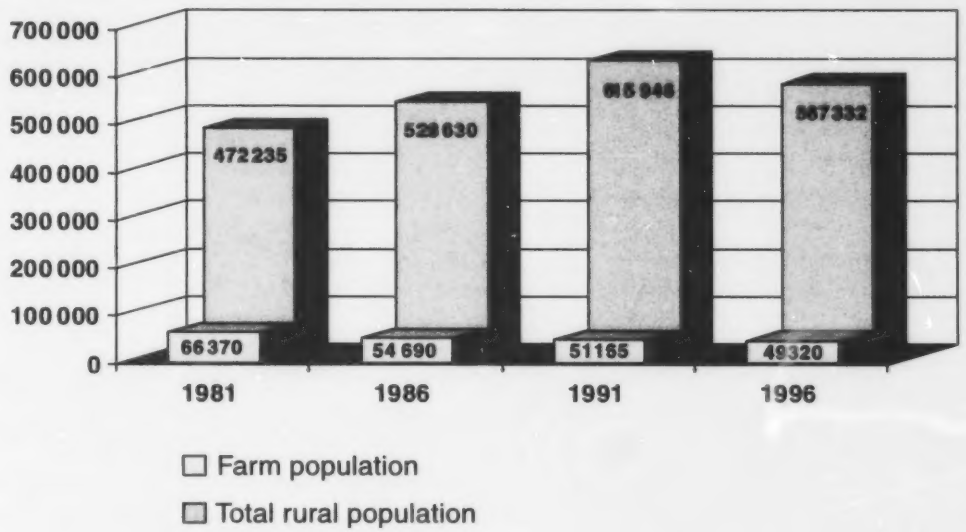


Source: Ontario Ministry of Finance (1995)

Rural areas have fewer farmers and more non-farm residents than in previous years.

Over the past two decades, rural areas within the Lake Ontario watershed have been undergoing major changes in the nature of their populations and land ownership. As shown in Figure 18, the total rural population (which includes villages up to 1 000 people) has grown by approximately 100 000 people since 1981. The decline in total rural population in 1996 reflects the incorporation of some of the rural areas into urban centres, most notably in Peel and York regions.

Figure 18. Farm and rural populations in Lake Ontario watershed counties



Source: Statistics Canada, Census of Agriculture, 1996

In contrast to this rising rural population, the population of farmers is declining steeply, with a loss of 25 percent over just 15 years. This reflects in part a move to larger farm units for economic reasons. It also includes some of the farmland base that has been converted to urban uses. However, the major factor in changing rural populations is almost certainly the spread of rural estate lots into farming areas, with the result that almost all counties are increasingly dominated by non-farm residents. This pattern appears in every county within the watershed, suggesting that the spread of rural severances and estate subdivisions is not limited to near-urban settings.

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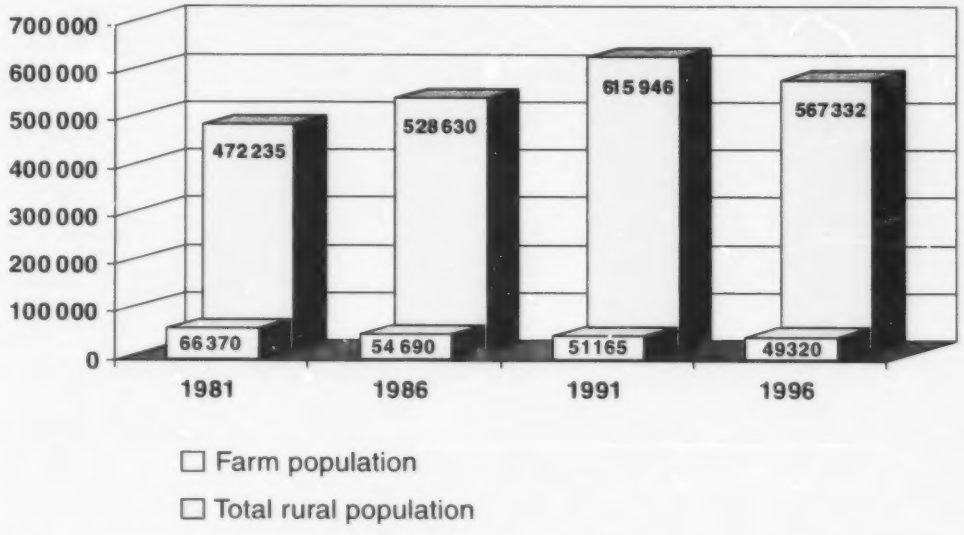

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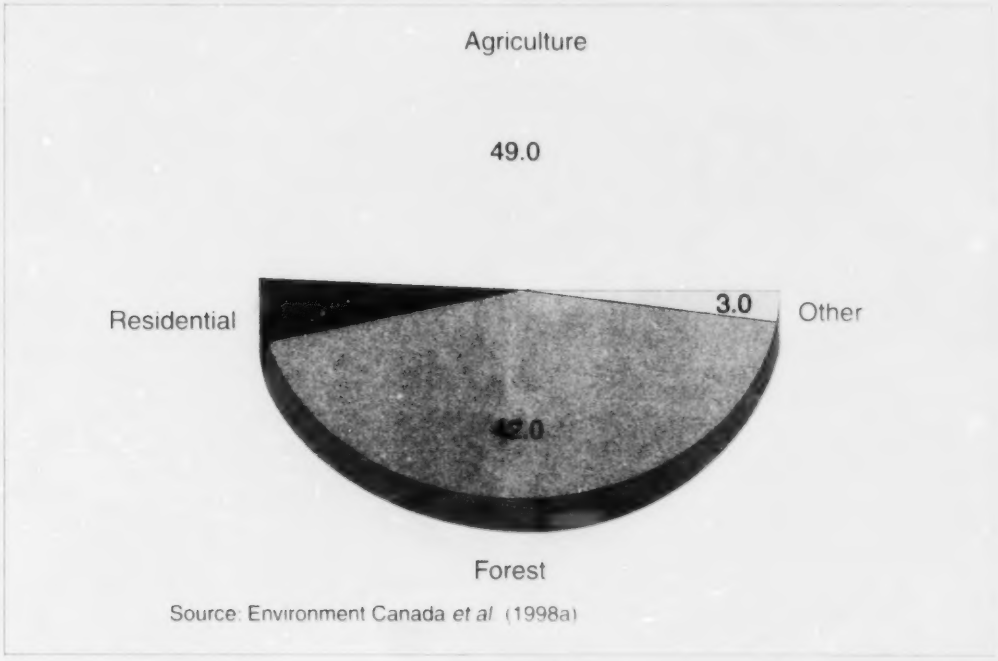
Land Use

Despite urban growth, agriculture and forestry still dominate land use within the Lake Ontario basin.

The Lake Ontario watershed is home to Canada's largest urban and industrial concentration, often called the "Golden Horseshoe" because it wraps around the western end of the Lake. However, the majority of the central sections of the watershed is in long-term agricultural use, and the northern sections are almost totally forested. Current land use is the result of a mix of factors (landscape capability, location with respect to resources or urban markets, transportation facilities, and various social preferences. A broad overview of current land use is shown in Figure 19. Because of the influence of the Canadian Shield in the northern parts of the watershed, forest cover is relatively high compared to agricultural southern Ontario.

Figure 19. Land use in the Lake Ontario Canadian watershed (percent)



Source: Environment Canada *et al.* (1998a)

The impacts of land use on fish and wildlife habitat are substantial, but vary considerably with the type and intensity of use. A background paper on land use prepared for the State of the Lakes Ecosystem Conference (SOLEC) in 1996 (Thorp *et al.* 1996) identified a range of potential impacts:

- loss of vegetative cover, increase in impervious surfaces, polluted stormwater runoff, and soil erosion associated with urban development;
- disruption of coastal processes and habitats by the clustering of urban growth along the lakeshore area;

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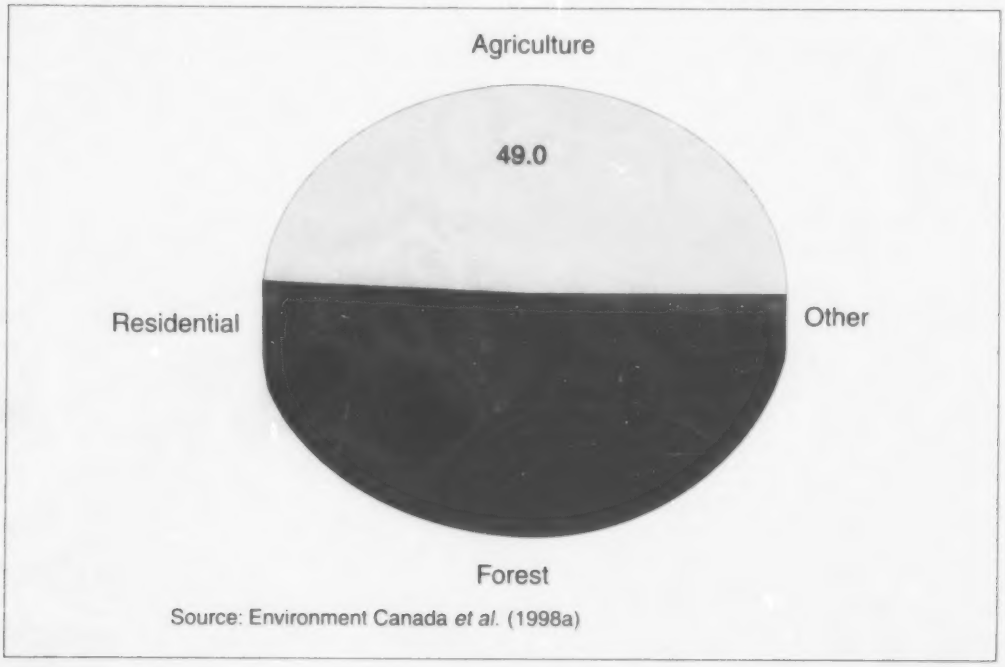

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- disruption of coastal processes and habitats by the clustering of urban growth along the lakeshore area;

- loss of farmland and natural areas to low-density urban sprawl, coupled with failure to clean up and re-use contaminated "brownfield" sites within existing urban areas;
- lhabitat losses, soil erosion and sedimentation, pesticide pollution, and manure runoff associated with agricultural land uses;
- lhabitat losses, polluted stormwater runoff, and air quality deterioration associated with the rapid expansion of highway transportation;
- lwastewater and stormwater discharges and municipal/industrial water use associated with urban and industrial areas; and
- lair discharges of pollutants from industrial operations.

Both urban and rural land uses are changing relatively rapidly in response to urban sprawl, loss of employment in city centres, and loss of farmland.

Information on land use change in southern Ontario is fragmentary and incomplete, despite the importance of understanding how these changes affect both economic and ecological systems. Several trends, however, appear to be significant within the Lake Ontario basin (drawn largely from Thorp *et al.* 1996):

- Urban sprawl is continuing around almost all existing cities (particularly Toronto), with most of the population growth occurring in low-density urban fringes. This trend is linked with rapidly rising use of automobiles for commuting.
- The city centres of major urban areas, notably Toronto, are rapidly de-industrializing, with business and employment migrating to suburban communities in the surrounding regions. This holds true both for traditional heavy industries, such as those in the Toronto Portlands, and for office employment.
- The pattern for transportation of goods continues to change quickly, with increasing cross-border commodity flows, decreasing reliance on water-borne and rail transport, and rapidly increasing highway usage.
- Conversion of farmland to non-farm uses is a major issue, with an estimated net decline in Ontario farmland of 9.1 percent in the decade from 1981 to 1991. A significant part of this decline is related to urban expansion (the Golden Horseshoe region has lost 14 percent of its agricultural cropland since 1981.

In a paper titled Changing Agricultural, Economic and Social Patterns in the Ontario Countyside, Fuller (1996) notes that the rural communities of southern Ontario are being transformed into a more open society. Rural people are more mobile in recent years, more likely to travel to jobs, shopping, or recreation. At the same time, jobs themselves are more mobile, since information technology has made urban proximity less essential. Rural communities have become more "spatially diverse", with people less restricted to a single town. Fuller also observes that rural settlement patterns are no longer attached primarily to farming.

Rather, such factors as commuting, tourism, and second homes determine the way in which people array themselves on the rural landscape.

For habitats, these changes are likely to mean increasing pressure on forested sites and scenic landscapes, where rural homes are judged to be most desirable.

One recent study of land use change from 1976 to 1995 took place in the southern half of the Niagara Escarpment Planning Area, set within the regions of Niagara, Hamilton-Wentworth, Halton, and Peel (Geomatics International 1997). This study used Landsat imagery to map areas of various land cover classifications, so that changes over time could be compared. While the Niagara Escarpment has a more protective land use control system than most parts of the Lake Ontario watershed, the study findings reflect the broader trends discussed above:

- ntensive row crop agriculture declined by 2.7 percent, with major losses concentrated in the Niagara Peninsula and Hamilton-Wentworth areas.

- Forested areas increased slightly across the study area, with increases being noted especially in the Halton and Peel sections of the Niagara Escarpment.

- Urban areas increased from 3.5 percent of the study area to 5.0 percent, particularly in the Hamilton-Wentworth area and the adjacent section of Niagara Region.

- Several urban-shadow land uses also increased significantly, including quarries and recreation areas such as golf courses.

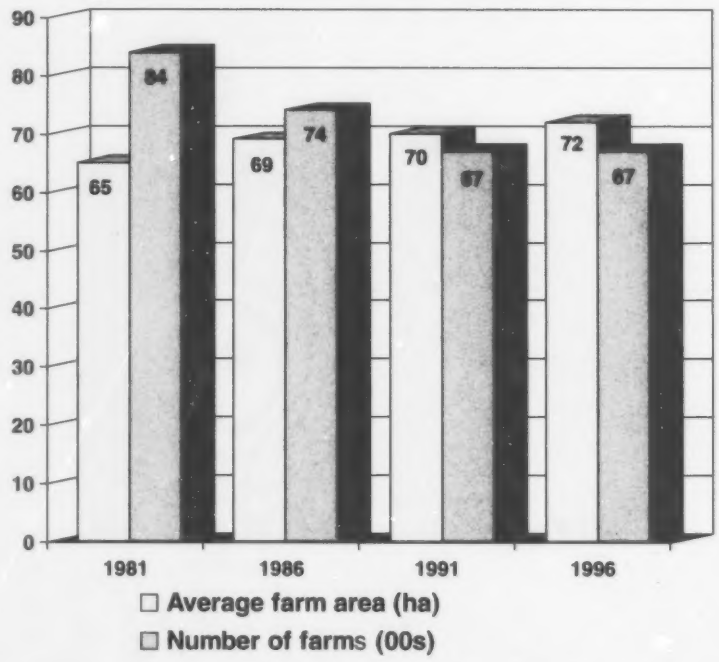
Trends in Agriculture

The number of farms and total area farmed are dropping, while average farm size is rising.

Agriculture is the dominant land use in most areas south of the Canadian Shield within the watershed. However, the economics of the agricultural industry are highly cyclical, and often marginal. As a result, over the past several decades there has been a steady decline in the total area being farmed within the watershed, and in the number of farm operations (Figure 20). This is a similar pattern to the more intensive farmland in the Carolinian region, but less pronounced (Reid *et al.* 1996). In the Lake Ontario watershed, farmland is being lost at both ends of the spectrum: some of the most productive soils are being lost to urban sprawl, and some of the least productive are returning to forest as they become uneconomical to farm.

With the remaining farms becoming fewer but larger, there is a general trend towards more intensive management, including the introduction of larger production units for hogs, beef, and poultry. These pose particular environmental challenges with regard to proper manure management.

Figure 20. Changes in farm number and size: 1981 to 1996



Source: Ontario Ministry of Agriculture, Food and Rural Affairs (1990,1996)

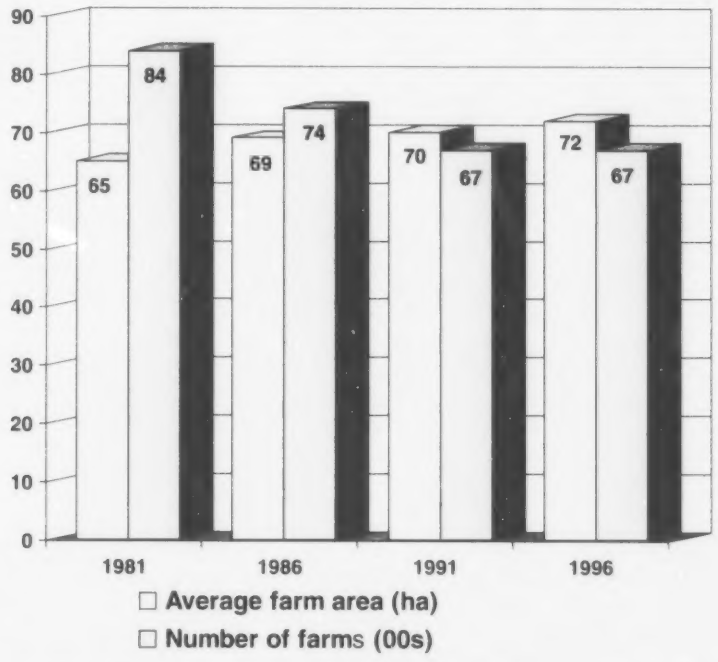
Farming practices are more intensive in the western third of the watershed, and intensity has changed little in the past two decades.

Census farms include a wide variety of habitats farm woodlots, pockets of wetland and scrub, grasslands and pastures. They also include large areas of more intensive row crops which are of relatively low benefit to wildlife, and which result in most of the agricultural pollutants such as sediment, nutrients, and pesticides that enter tributary streams.

As Figure 21 shows, the percentage of cropland within active farms varies considerably across the Lake Ontario basin. In general, a strong pattern from southwest to northeast emerges, with over 70 percent of Hamilton-Wentworth's farmland in crops, compared to only 12 percent in Haliburton. Even the most intensive farmlands within the Lake Ontario basin, however, are significantly lower in cropland than counties such as Essex in the extreme south west of Ontario, at 93 percent. It should be noted that counties which straddle the Shield edge, such as Peterborough and Hastings, likely have cropland values in their southern reaches similar to Northumberland.

Two areas deserve special mention because of the different type of agriculture practiced in these locations. Niagara Region is the premier specialty fruit-growing area for Ontario, with large acreages of peaches, grapes, and other tender fruits. The southern part of Northumberland County is also a fruit-growing area, primarily with apple orchards.

Figure 20. Changes in farm number and size: 1981 to 1996



Source: Ontario Ministry of Agriculture, Food and Rural Affairs (1990,1996)

Farming practices are more intensive in the western third of the watershed, and intensity has changed little in the past two decades.

Census farms include a wide variety of habitats farm woodlots, pockets of wetland and scrub, grasslands and pastures. They also include large areas of more intensive row crops which are of relatively low benefit to wildlife, and which result in most of the agricultural pollutants such as sediment, nutrients, and pesticides that enter tributary streams.

As Figure 21 shows, the percentage of cropland within active farms varies considerably across the Lake Ontario basin. In general, a strong pattern from southwest to northeast emerges, with over 70 percent of Hamilton-Wentworth's farmland in crops, compared to only 12 percent in Haliburton. Even the most intensive farmlands within the Lake Ontario basin, however, are significantly lower in cropland than counties such as Essex in the extreme south west of Ontario, at 93 percent. It should be noted that counties which straddle the Shield edge, such as Peterborough and Hastings, likely have cropland values in their southern reaches similar to Northumberland.

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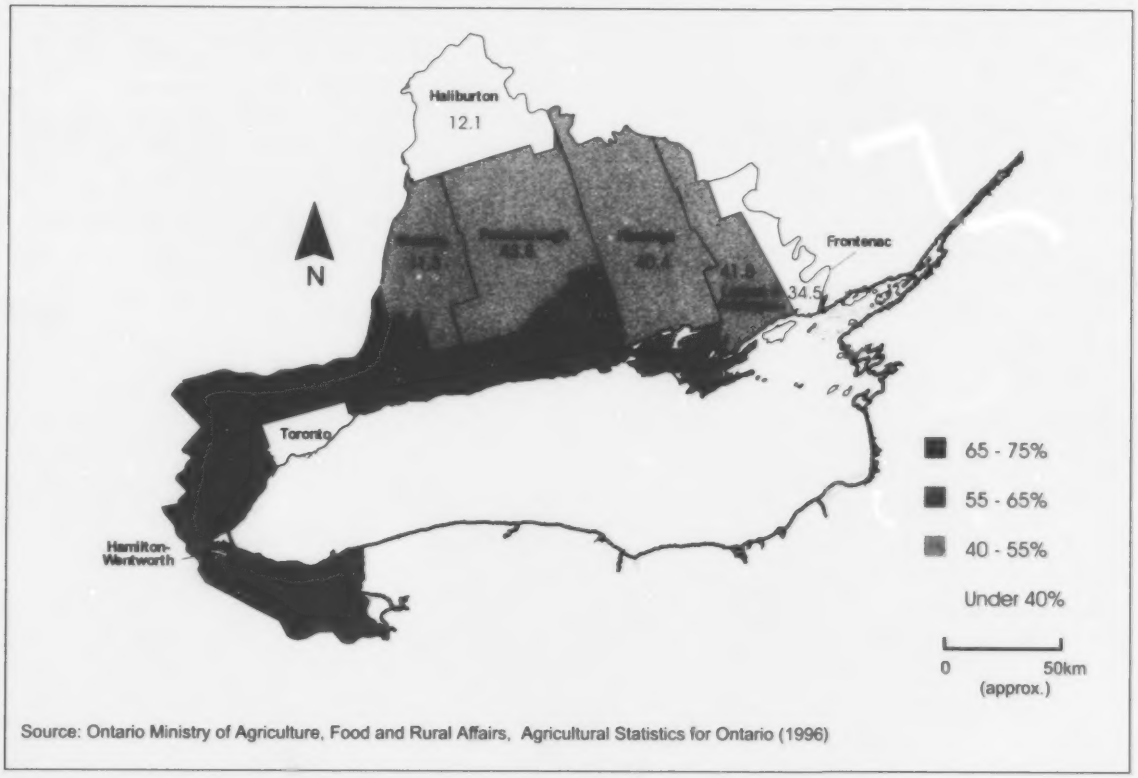
Figure 21. Percent of active farmland under crops: 1996



Source: Ontario Ministry of Agriculture, Food and Rural Affairs, Agricultural Statistics for Ontario (1996)

Within the farmlands of the Carolinian region, a marked trend towards more intensive agricultural practices was noted over the past two decades (Reid *et al.* 1996). However, that trend is much less pronounced in the Lake Ontario basin, as shown in Table 9.

Table 9: Area of cropland as a percent of total census farm area: Lake Ontario watershed counties

1981	1986	1991	1996
52.0	51.9	53.5	53.4

Source: Ontario Ministry of Agricultural, Food and Rural Affairs, Agricultural Statistics for Ontario 1990, 1996

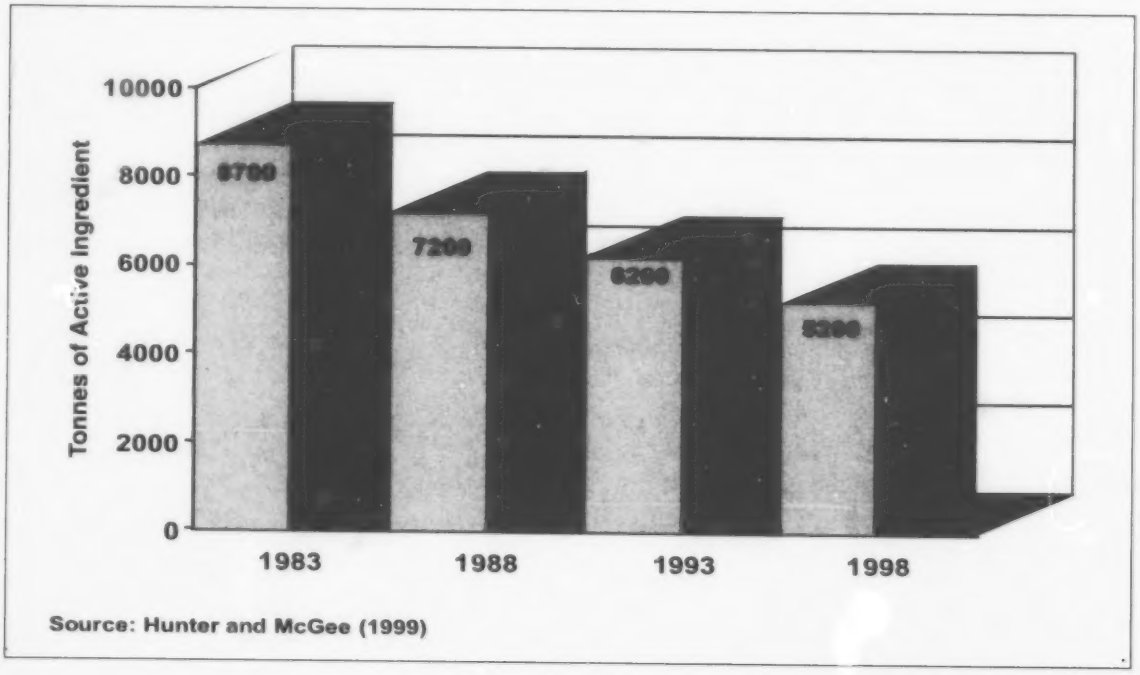
The total amount of pesticide use on Ontario farms is declining.

A recent report on pesticide use on Ontario farms (Hunter and McGee 1999) shows that the amount of total active ingredient applied and the amount applied per hectare have both been steadily declining since 1983 (Figure 22). This pattern covers a mix of trends for individual pesticides, with atrazine and metolachlor applications remaining fairly constant over the past five years, and glyphosate use rising significantly, up four-fold since 1988. Pesticide use in fruit and vegetable crops was down in 1998 from earlier levels, especially for insecticides. The application rate for fungicides on fruit crops is the only product showing significant increases.

Newer, high efficacy pesticides are being used more widely in recent years. These products are applied at gram per hectare rather than kilogram per hectare rates and some of these herbicides are acutely phytotoxic at levels below the limits of analytical detection. This, at least partially, accounts for the reduced total amounts of pesticide used. Given the increased toxicity of some of these newer pesticides, it is unclear at this time whether the overall toxicity loads of these pesticides on Ontario farms have also declined.

While these data are for Ontario as a whole, county-level data for 1998 use shows that pesticide use within the Lake Ontario basin reflects closely the degree of agricultural intensity. One anomaly to this pattern is the region of Niagara, where the fruitlands receive relatively high application rates of pesticides.

Figure 22. Pesticide use on Ontario farms: 1998



Airborne Stressors

Levels of most airborne pollutants affecting the Lake Ontario basin are stable or declining, with the exception of ground-level ozone.

The lands and waters of the Lake Ontario basin are affected by pollutants that are dispersed by air. For some pollutants, a major portion of the total arrives from outside the watershed or even the country; for example, 50 percent of Ontario smog is estimated to originate in the United States (Ontario Ministry of the Environment 1999a).

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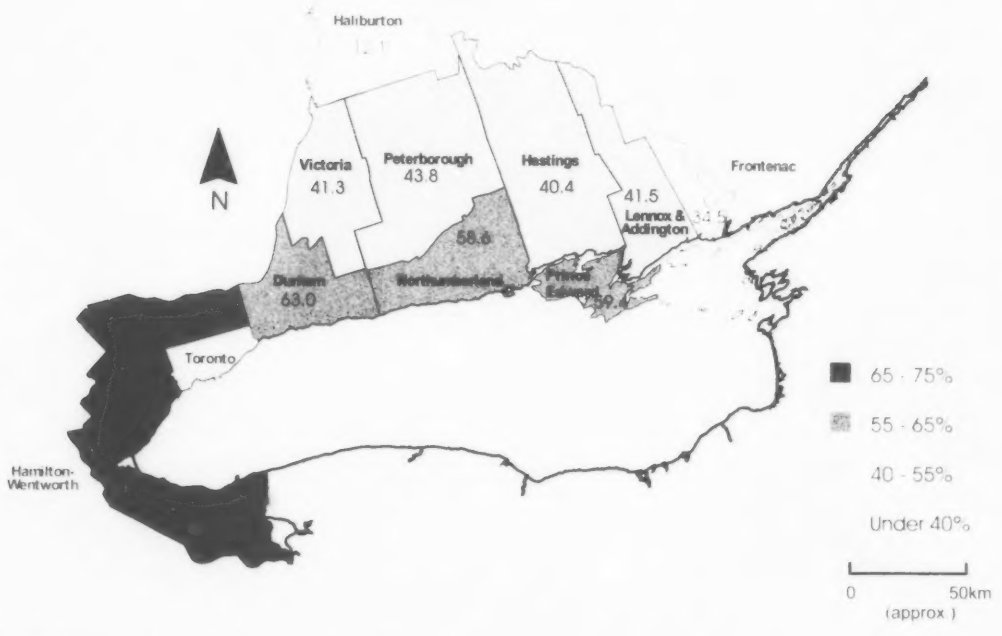

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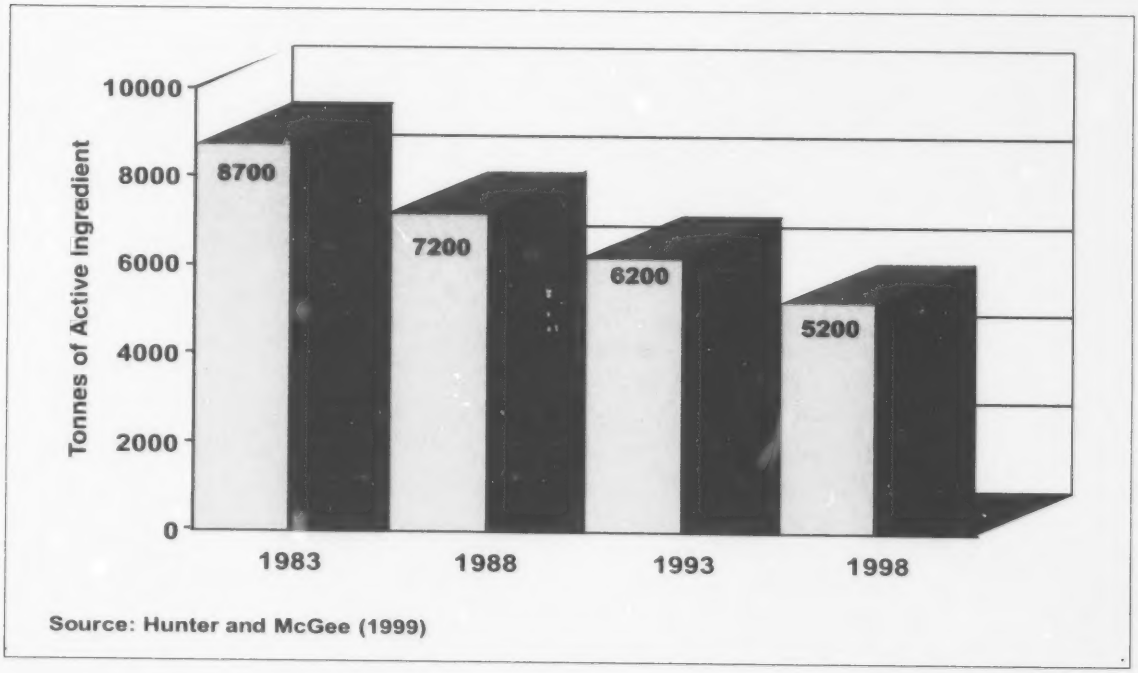

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Long-term monitoring of air pollutants is carried out by the Ontario Ministry of Environment, with the most recent results summarized in the report Air Quality in Ontario 1997 (Ontario Ministry of the Environment 1999a). As well, Environment Canada takes part in a binational monitoring and research program called the Integrated Atmospheric Deposition Network (IADN), which tracks trends in air and precipitation concentrations at stations across the Great Lakes basin (US/Canada IADN Scientific Steering Committee 1998). Several types of airborne pollutants create ecological stress within the Lake Ontario watershed ecosystem:

- Ozone is a major component of summer smog which causes damage to agricultural crops, forests and natural vegetation. Mean annual ground-level ozone levels for southern Ontario have shown an overall increasing trend from 1979 to 1999. High ozone levels are a widespread pattern; for most of the year, levels are actually higher in northern Ontario than in the south. A significant part of this stressor originates in the United States.

- Total suspended particles, which arise from industrial processes involving combustion or incineration, vehicle exhausts and road dust, and natural sources such as forest fires, cause damage to vegetation, deterioration in visibility (e.g., haze/smog), and contamination of soil. Trace metals such as iron, copper, and manganese, along with sulphates, are often attached to the suspended particles. Over the period from 1992 to 1997, neither the ambient levels of suspended particles or trace metals in six urban sites showed any significant change.

- Sulphur dioxide and nitrogen dioxide are gases that lead to acid deposition, which causes lake acidification, corrosion, haze, and damage to tree leaves and crops. From 1971 to 1997, Ontario sulphur dioxide emissions dropped 78 percent, while the average levels in the province (taking into account transboundary emissions) improved by 82 percent. Nitrogen dioxide ambient levels declined during the 1980s, but have remained relatively constant throughout the 1990s.

- A review of early results from IADN monitoring suggest that most semi-volatile organic compounds (which react with nitrogen oxides to form ozone) and trace metals are showing downward trends in concentrations.

- Atmospheric loadings are a significant source for most of the Lake Ontario critical pollutants identified through the Stage 1 Lakewide Management Plan (LaMP) process though much larger sources for these pollutants are the other Great Lakes and the Niagara River basin (Environment Canada *et al.* 1998a). Airborne transport is significant for PCBs (polychlorinated biphenyls), total DDT (dichlorodiphenyltrichloroethane), dieldrin, and dioxins, in part by direct deposition on the lake, and in part by deposition and subsequent transport through watersheds. It is interesting to note that with substantial atmospheric and water-borne loadings, Lake Ontario appears to be acting as a significant source for these pollutants, as they volatilize from the lake surface into the atmosphere.

Climate change has the potential to create enormous future stress on the natural forest ecosystems of the watershed.

Long-term changes in atmospheric dynamics, notably climate change, are likely to also place enormous stress on the Lake Ontario watershed. With current climate change models suggesting an average warming of 2 to 5 degrees by the end of the 21st century, major disruptions in the health and distribution of forest communities can be expected (Smith *et al.* 1998). Rapid climate change could cause massive tree dieback in the mixed forests of southern Ontario, increased wildfire rates, the extinction of some woodland herbs, and increased damage from pests and diseases. Fragmented habitats, such as those in the southern sections of the Lake Ontario watershed, are likely to be most vulnerable to species extinctions and other ecological disruptions.

The magnitude and timing of climate change stress is still uncertain, but it has the potential to create changes that echo throughout the ecosystem, and dwarf the scale of current stressors.

Exotic Species

Invasive exotic (non-native) species affect the quality of upland habitats, particularly within urban areas.

Non-native plant species are widespread and increasing within many upland and wetland habitats, especially those within urban areas and those that are fragmented. Species such as garlic mustard, dog-strangling vine, purple loosestrife and common buckthorn crowd out native understory plants and have become very abundant in many urban wooded and wetland areas. The effects of this competition on urban biodiversity and forest regeneration are substantial, and greater emphasis on finding effective controls for exotic species in these settings is needed.

2.5 Summary of Impairment, Information Gaps, and Emerging Issues

- The loss of upland forest habitats south of the Shield is emerging as a major conservation issue, with "original woodlands" now at less than six percent of the landscape and declining and old-growth woodlands almost extinct.
- Forest cover has been fragmented in most areas south of the Shield to levels that do not support the full range of native wildlife, and ongoing fragmentation is one of the most pressing habitat issues in the watershed.
- Historic wetland losses in the western and southern sections of the watershed have reduced their original extent by more than two-thirds, with most other areas south of the Shield reduced by approximately one-half. Remaining wetland concentrations are associated with the Peterborough drumlin field, the edge of the Shield, and the Niagara Escarpment.
- Updated and standardized information bases are especially needed for woodlands, grasslands, and wetland habitats, so that recent trends in their distribution and extent can be tracked. For example, the last comprehensive database for wetlands occurrence dates from 1982; for upland forests, the last reliable database is 1978. Extensive land use changes have taken place since then, together with new provincial and municipal policies and stewardship programs. Digitally-based databases, compiled using methods to allow comparisons with earlier data, are essential to effective conservation efforts.
- The richest priority bird areas mostly occur in the northern sections of the watershed, but thus far, designated IBAs are mostly associated with the coastline, suggesting that future IBAs might be designated for forest birds in the north.
- Sixty-one kinds of rare vegetation communities are clustered along the Niagara Escarpment and in the Northumberland-Hastings area, with forest/woodland, limestone cliff/talus, wetland, prairie and alvar habitat types most represented.
- Rare species are distributed broadly across the watershed, with a particular concentration in the Niagara Region. Species at risk include those associated with rare community types, those at the northern limits of their range, and grassland and interior forest birds.
- Future human population growth is expected to focus primarily on the Golden Horseshoe area, and could result in significant further losses and degradation of habitats in that area.
- While agriculture is still a dominant land use within the watershed, rural non-farm landowners and recreational users are increasingly significant players in the rural landscape across the watershed.
- Airborne pollutants are a significant stressor in the watershed, and climate change has the potential to create enormous future stress.
- Overall, much of the habitat within the Lake Ontario watershed is significantly degraded and under continuing stress. Major rehabilitation programs would be necessary to achieve the habitat objectives identified for AOCs across the rest of the landscape.

3.0 Lake Ontario Tributaries

3.1 Habitat Characteristics and Historical Changes

The Canadian tributaries to Lake Ontario contribute only about seven percent of the annual water inputs to the Lake, with about one third of that from the Trent River. In contrast, the Niagara River and Welland Canal contribute a volume equal to approximately 85 percent of the total outflow down the St. Lawrence River (Stevens 1988). Nonetheless, the tributaries are a very significant part of the lake ecosystem. The principal spawning and nursery habitats for one-third of the fish species in the Great Lakes are located in the tributaries (Lane *et al.* 1996). Aquatic habitats within the tributaries also significantly increase the diversity of fish species and other fauna – 125 fish species are known to occur within Lake Ontario tributaries, compared to a total of 95 in the Lake itself (Bailey and Smith 1981).

Within the Lake Ontario basin, tributary streams can be generally classed into four groups:

- The Welland River, which discharges into Lake Ontario through the Niagara River and the Welland Canal, is a relatively sluggish, low-gradient waterway, with high summer water temperatures and high suspended sediment levels.

- A series of short, relatively steep streams have their headwaters along the Niagara Escarpment and Oak Ridges Moraine, and then flow across flat till plains to discharge into the Lake. Most of these streams (such as the Credit River, Rouge River, Duffins Creek, Ganaraska River, etc.) have strong groundwater-fed baseflows in their upper reaches, with cold-water conditions suitable for brook trout. Many of these tributaries provide extensive nursery and rearing areas for migratory salmonids, such as rainbow trout and chinook salmon, which contribute to the sport fishery of the Lake. Some of these streams have been degraded in their lower reaches by agricultural and urban land uses.

- The Trent River system is the largest north shore tributary by far, contributing 33 percent of the total Canadian tributary flow to the Lake. The Trent River collects water flowing north and east off the Oak Ridges Moraine, with high quality coldwater streams like Cold Creek and the Otonabee River, as well as rivers flowing down off the Canadian Shield such as the Burnt River, Indian Creek, and the Crowe River. The main channel of the Trent River has been historically modified as part of the Trent-Severn Canal, and includes significant stretches of riverine wetland as well as warm-water habitats.

- Several other major tributaries flow into the Bay of Quinte, including the Moira River and Salmon River. These rivers arise on the Canadian Shield and have the lower half of their extent on limestone plain, and offer primarily warm-water habitats in their mainstems with scattered cold-water tributaries throughout their basins.

To date in Ontario, aquatic communities have not been classified into a broadly-accepted hierarchy to assist in planning, protection, and management activities. The initial steps are now underway to do so, based largely on similar work on the U.S. side of the Great Lakes basin. An

aquatic ecoregion classification for Ontario has recently been outlined (Mandrak 1999). This approach groups tertiary watersheds with similar characteristics of bedrock geology into five ecozones, and then further subdivides these into 10 ecoprovinces and then into 15 ecoregions. These ecoregions show reasonable correspondence with a fish faunal classification for the province developed by N. Mandrak from a Royal Ontario Museum collections database.

Most of the Lake Ontario watershed falls within the "Lower Great Lakes aquatic ecozone", which is not further subdivided into ecoprovinces or ecoregions. This ecozone is the warmest and wettest of the five in the province, and its geology is primarily sedimentary covered with glacial deposits. Inland lakes within the ecozone are small and shallow, and its streams have the lowest, least variable annual flows and the highest water chemistry values.

The Moira River and Cameron Lake drainages are within the "Shield aquatic ecozone", which is described as moderately cold and wet. As the name implies, watercourses within this zone are based largely on the igneous rocks of the Canadian Shield. Inland lakes are relatively small but deep. Mean annual streamflow is moderate in its volume and variability, but such factors as alkalinity, conductivity, dissolved oxygen, pH and turbidity are all significantly lower than in the Lower Great Lakes aquatic ecozone.

Subsequent stages of the aquatic classification approach have been applied on the American side of the Great Lakes basin, with testing in several Michigan watersheds (Higgins *et al.* 1998, 1999). This approach subdivides aquatic ecoregions into macrohabitat types, based on surficial geology, local physiography, and the size, shape, and network position of streams. For example, stream macrohabitat boundaries are based on 1) a significant size increase on a mainstem, 2) the confluence of a tributary stream to its mainstem, 3) the confluence with a wetland complex, and 4) the confluence with a lake. Finer levels of this classification hierarchy, which have not yet been generally applied, use abiotic features to define habitat units, and biotic factors to characterize aquatic communities into alliances and associations.

In Ontario, most of the recent effort has been directed to characterizing fish communities and habitat attributes within streams at the site scale, and a stream assessment protocol to provide a consistent approach at that scale has been developed (Stanfield *et al.* 1999). In the Toronto region, the Toronto and Region Conservation Authority (TRCA) and the Ontario Ministry of Natural Resources (OMNR) have been using a landscape-based aquatic habitat classification as a basis for fisheries management plans for several years (Toronto and Region Conservation Authority 1996).

In conjunction with other agencies, the Salmonid Ecology Unit of the OMNR is working to develop predictive models for fish habitats at the catchment, valley, or reach scales (L. Stanfield, pers. comm.). This kind of valley segment classification will be comparable to recent work in Michigan's Lower Peninsula, which used valley characteristics to predict corresponding fish communities (Seelbach *et al.* 1997; Higgins *et al.* 1998), and will be carried out in collaboration with The Nature Conservancy of Canada (NCC). The NCC will use the results of this assessment on the Canadian portion of the Great Lakes basin to identify an assembly of priority areas for protection based on a habitat quality and threats analysis, and to convene partners to develop conservation strategies (J. Riley pers. comm.).

There appears to be little question that effective conservation strategies for tributary streams are urgently needed. Tributary streams have been adversely affected since early in the history of European settlement within the basin (Sly 1991). In the first period of settlement, the construction of mills and dams on most tributaries limited fish movement and added large quantities of effluents with high Biological Oxygen Demand. Deforestation of watersheds reduced groundwater flows, caused higher summer stream temperatures and more rapid temperature changes, and created greater extremes in high and low flow conditions. Early agriculture, especially during the "Barley Years" in the 1860s, flushed very high levels of sediments down tributary streams.

The combination of these factors undoubtedly had negative effects on many aquatic life forms, but were particularly deadly for Atlantic salmon (Christie 1973). This species, which was probably a land-locked form indigenous to Lake Ontario, was abundant in 1830, mostly as a fall spawner. By the mid-1860s, very few were caught, and the species was extirpated by 1900.

Over the past two centuries, habitat loss, pollution, exotic species introductions, and alteration of natural flow regimes from dams, channelization, and various land uses have had catastrophic impacts on the biotic and abiotic components of aquatic ecosystems, including tributaries (Ward and Stanford 1989; Richter *et al.* 1997; Higgins *et al.* 1998). In the United States, aquatic ecosystems are home to more than half of all of North America's known imperiled and vulnerable animals, with freshwater mussels, crayfish, amphibians, and fishes the most at-risk taxonomic groups (Stein and Chipley 1996; Ricciardi and Rasmussen 1999). Over two-thirds of freshwater mussel and half of the crayfish species are considered imperiled or vulnerable.

A recent study of freshwater mussels in the Canadian waters of the lower Great Lakes basin showed a similar pattern in Ontario, with species losses and changing community composition throughout the basin (Metcalfe-Smith *et al.* 1998). While losses were especially evident in the species-rich Lake Erie and Lake St. Clair drainages, the same trends were found in the Moira River system in the Lake Ontario basin.

3.2 Defined Habitat Goals for Tributaries

The framework of rehabilitation guidelines developed for Great Lakes Areas of Concern (Environment Canada *et al.* 1998b) provides goals for riparian habitats along tributaries that could have application across the watershed:

Table 10: Summary of riparian habitat rehabilitation guidelines for Great Lakes Areas of Concern

Parameter	Guideline
Percent of stream naturally vegetated	75% of stream length should be naturally vegetated.
Amount of natural vegetation adjacent to streams	Streams should have a 30 m wide naturally vegetated buffer on both sides.
Total suspended sediments	Suspended sediment concentrations should remain below 25 mg/l for the majority of the year.
Percent of an urbanized watershed that is impervious	Less than 15% imperviousness in an urbanized watershed should maintain stream water quality and quantity, and leave biodiversity relatively unimpaired.
Fish communities	Targets are set based on knowledge of underlying characteristics of watershed (drainage area, surficial geology, flow regime), historically and currently occurring fish communities, and factors presently impacting the system and their relative magnitudes.

Additional goals which relate closely to the health of tributary habitats are expressed through the Provincial Water Quality Objectives (Ontario Ministry of the Environment 1999b). Among many others, these include objectives for maximum desirable concentrations of various substances, such as:

Total phosphorus concentrations:	30 mg/l
Copper concentrations:	5.0 ug/l
Zinc concentrations:	20 ug/l
Benzo(a)pyrene concentrations:	210 ng/l
Lindane concentrations:	10 ng/l
Polychlorinated biphenyl (PCB) concentrations:	1.0 ng/l
Aldrin/Dieldrin concentrations	1.0 ng/l
Hexachlorobenzene (HCB) concentrations	6.5 ng/l
Mirex concentrations	1.0 ng/l

These objectives provide a quantitative basis for measuring pollutants that could impact the health of the aquatic ecosystem, since they are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycle.

3.3 Current Status and Recent Trends

Riparian Cover

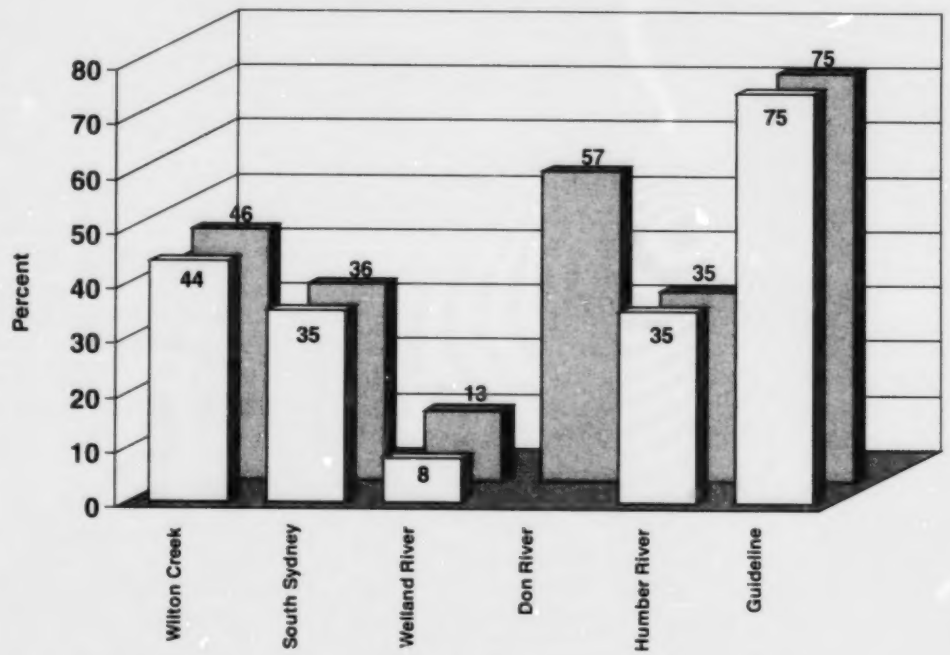
Few streams south of the Canadian Shield meet the habitat rehabilitation guidelines for riparian cover in Areas of Concern.

Tributary valley and stream corridors provide many important hydrologic and other ecological functions, particularly when they remain in forest or other natural cover. These include:

- conveyance and provision of storage for storm and melt waters;
- recharge and discharge areas for groundwater;
- nutrient and sediment transport;
- water quality and nutrient regulators;
- provision of fish and wildlife habitat and migration routes;
- air quality improvement;
- noise level attenuation;
- creation of microclimates; and
- maintaining a genetic pool for native flora and fauna (Ontario Ministry of Natural Resources 1991; Metro Toronto and Region Conservation Authority 1994).

Most of these benefits are dependent on the width of the vegetated buffer in the riparian (stream-side) zone (Castelle *et al.* 1994; O'Laughlin and Belt 1995). For streams within Ontario Areas of Concern (AOCs), a vegetated buffer at least 30 metres in width on both sides of the stream, and covering 75 percent of the stream length, has been proposed as an appropriate guideline (Environment Canada *et al.* 1998b). Comprehensive data on how well Lake Ontario tributaries meet this guideline are not available. However, data from five local area studies, as shown in Figure 23, suggest that few streams south of the Shield would meet this guideline. Maintaining vegetative buffers wider than 10 metres is especially difficult within urban areas (D. Dyce pers. comm.).

Figure 23. Riparian habitat conditions for selected Lake Ontario streams



Sources: Don Watershed Regeneration Council (1997), Environment Canada *et al.* (1998b)

Health of Fish Communities

Most tributary streams in the Lake Ontario watershed south of the Shield have impaired fish communities relative to their historic potential.

Fish communities provide good indicators of the overall health of stream ecosystems, since they integrate many habitat factors during their life cycles (Ontario Ministry of Natural Resources and Credit Valley Conservation Authority 1999). Fish community targets are often used as a framework for rehabilitation planning, but these expectations need to be based on several factors (Toronto and Region Conservation Authority 1998b):

- knowledge of the fundamental or underlying characteristics of the watershed or subwatershed (drainage area, surficial geology, flow regime) and what fish communities have historically been present;

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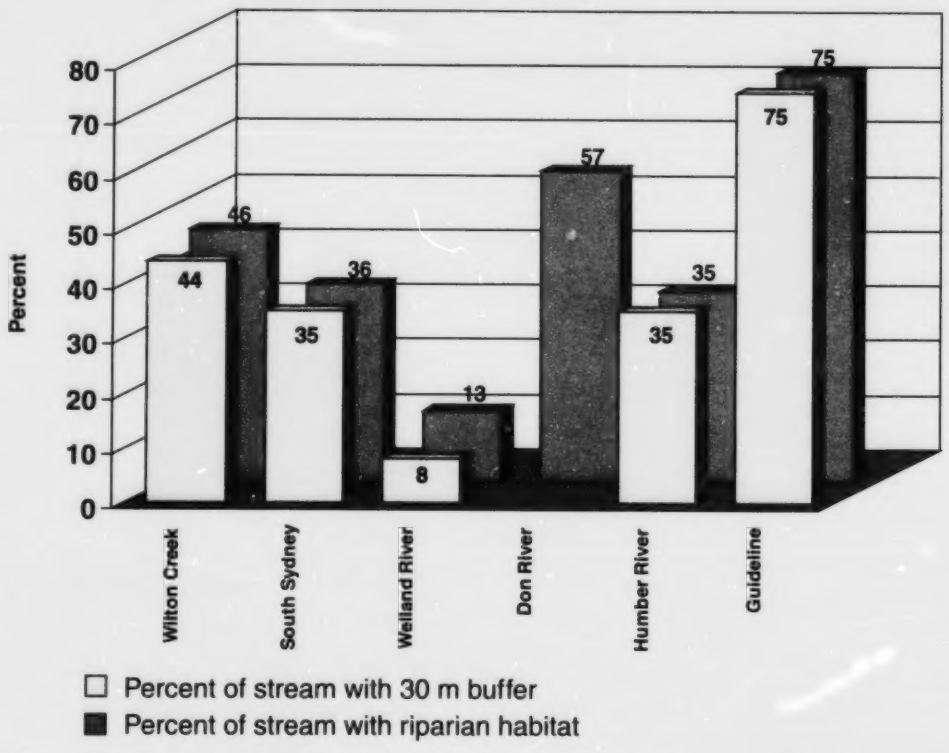

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- knowledge of the fundamental or underlying characteristics of the watershed or subwatershed (drainage area, surficial geology, flow regime) and what fish communities have historically been present;

- knowledge of what the system is presently supporting (existing fish community) and some idea of its condition; and

- knowledge of the factors presently impacting the system and their relative magnitudes.

The approach used by the TRCA identifies three habitat categories (cold water, cool water and warm water) within small, medium, and large drainage basins. Each of the habitat categories is related to the percentage of coarse soils in the drainage basin, baseflow ratio, and historic fish communities. Within each category, the number of expected species in various fish groups is identified, based on species richness relationships developed by Steedman (1988). To provide a better picture of the present health of the fish communities in individual habitat categories, the Index of Biotic Integrity (IBI) was used. The IBI integrates 10 measures of the fish community at a site and provides a score that can be compared between sites or to a generic scale of integrity (Steedman 1988).

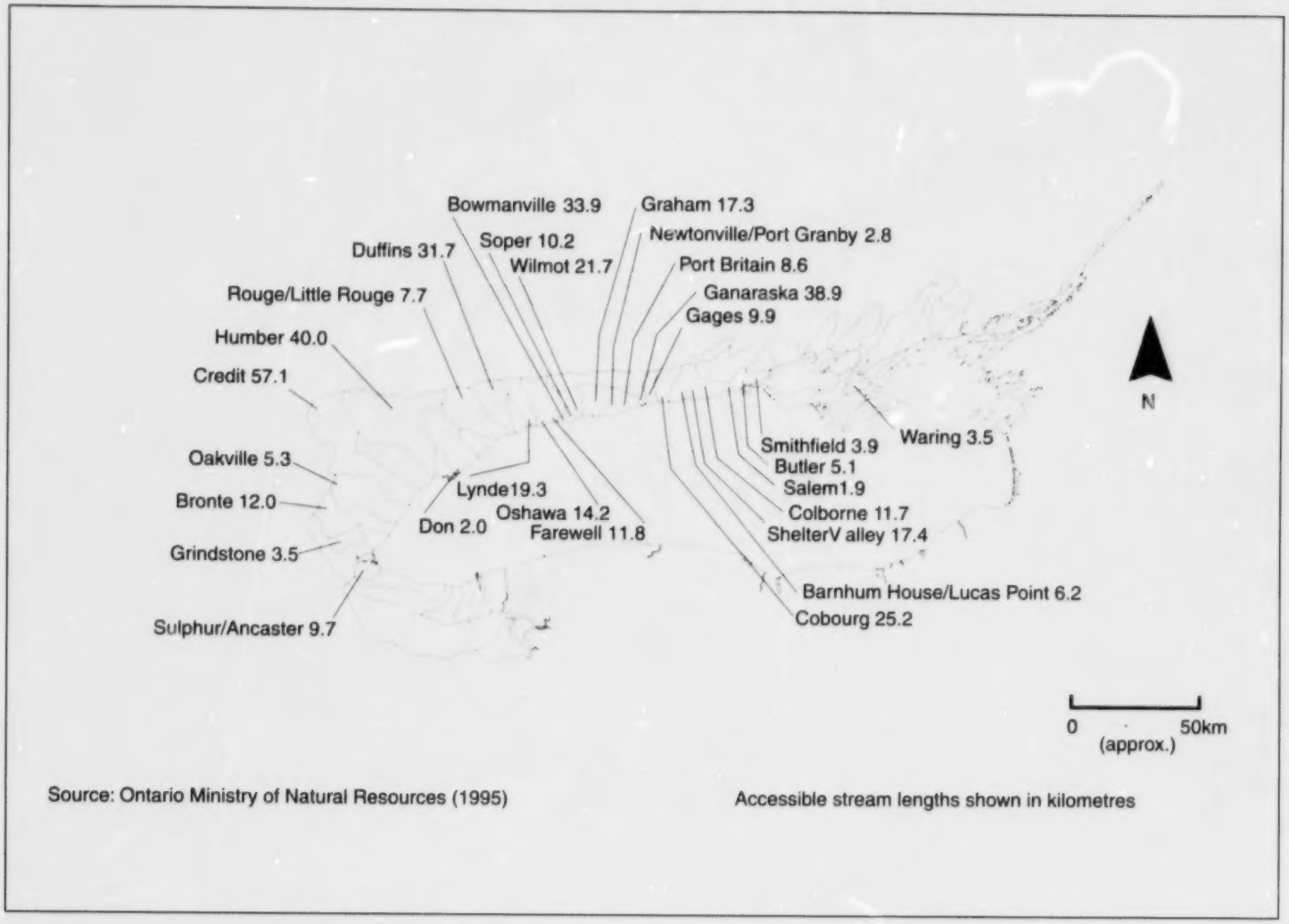
When this approach was tested on the Humber River watershed, 57 percent of the stations sampled scored poor or fair, with the remainder in the good range and one site in the very good range. The TRCA suggested that appropriate targets might be: fish communities appropriate for the habitat categories, and 75 percent of all stations scoring IBI of good to very good, with no stations scoring poor (Toronto and Region Conservation Authority 1998b).

This approach appears to have excellent potential for use elsewhere in the Lake Ontario watershed, as part of fisheries management plans or watershed report cards. One of the proposed products from the OMNR-NCC aquatic habitat partnership is a model to predict potential fish assemblages for each valley segment, which will provide a basis for applying the kind of analysis proposed by TRCA.

Mapping of coldwater fish communities, compiled from OMNR and conservation authority offices, is currently being compiled by OMNR in its Natural Resource Values Information System (NRVIS) and will be available before the end of 2000. In the Lake Ontario watershed, coldwater streams have a close association with landscape features, with almost all of them associated with the coarse-textured soils and high groundwater discharge areas of the Oak Ridges Moraine, Niagara Escarpment, and Lake Iroquois shoreline.

Coldwater stream habitats along the north shore of the Lake have a particular significance to Lake Ontario fisheries, since anadramous salmonids use these streams for spawning, rearing and nursery habitats. The length of accessible habitat, upstream to the first dam or other barrier, is important not only to non-native salmonids such as rainbow trout and chinook salmon, but also to the potential restoration of the native Atlantic salmon to the Lake (Lake Ontario Management Unit 1995). Figure 24 shows the length of accessible coldwater habitats in each tributary along the north shore.

Figure 24. Coldwater stream habitats accessible from Lake Ontario



Several species of threatened and vulnerable fish occur within Lake Ontario tributary streams.

Another measure of impaired fish communities is the number of associated aquatic species at risk. In the case of Lake Ontario tributaries, the recently-approved recommendations of the Committee on the Status of Species at Risk in Ontario include the following:

- listed as threatened: redside dace in tributaries on the west end of Lake Ontario; channel darter in the Moira River, Skootamata River, and Trent River; and

- listed as vulnerable: river redhorse in the Trent River (Ontario Ministry of Natural Resources 2000).

For a complete listing of species at risk, refer to http://www.cosewic.gc.ca/ and http://www.rom.on.ca/ontario/risk.html

3.4 Current Stressors and Impacts

Loadings of Sediments and Toxins

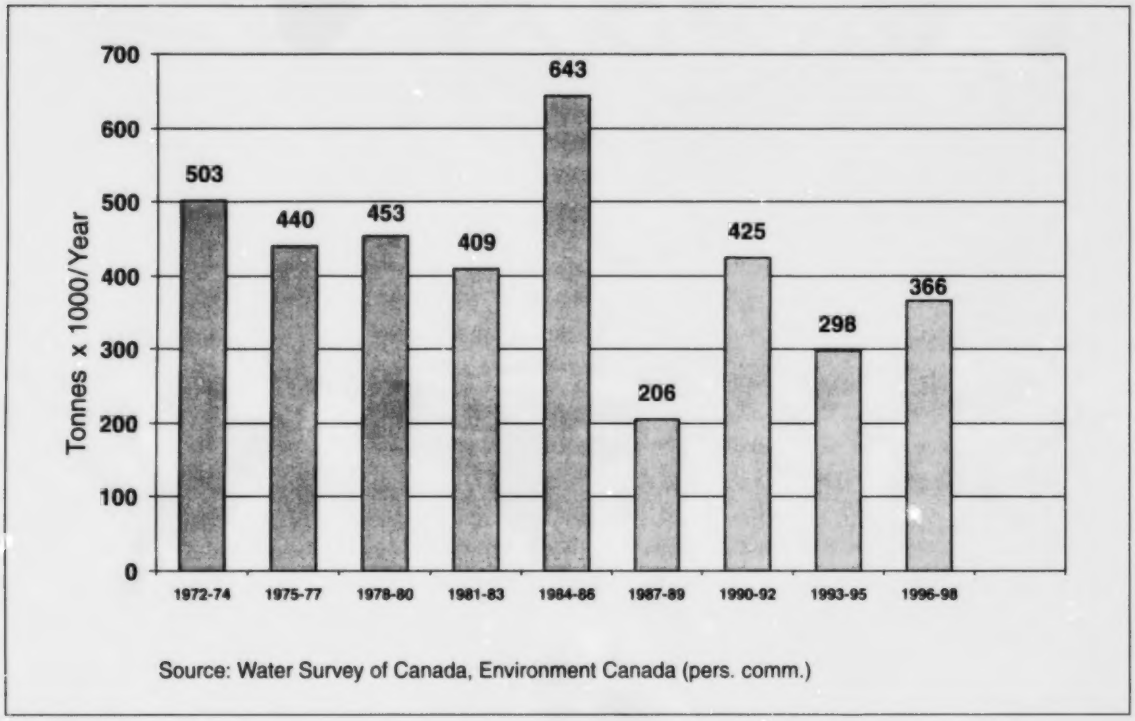
Over the past 26 years, suspended sediment loadings in most tributaries have declined significantly.

Sediment is one of the most visible and widespread pollutants within tributary streams. While sediment transport is a natural part of stream ecosystems, elevated levels of sediments from urban and agricultural runoff smother aquatic habitats. Other pollutants, such as nutrients and pesticide residues, often enter streams attached to fine suspended sediment particles.

Sediment loading into tributaries has been a long-term problem. Richardson (1944) remarked that as much as one metre of topsoil and sand from the Oak Ridges Moraine was lost to erosion during the early 1900s. The impacts of these massive sediment loadings on the streams have been long-lasting and are likely to affect the morphology of their channels for a long time to come (L. Stanfield pers. comm.). Sediment transport in Lake Ontario tributaries continues to be a significant factor controlling habitat quality in many streams, particularly in the lower gradient sections, which do not have the energy to move the bedloads of sand and other sediments received from upstream areas.

Annual sediment loadings vary considerably, related largely to weather patterns and the severity of storm events. However, data on suspended sediments supplied by the Water Survey of Canada show a gradual downward trend in sediment loadings from Lake Ontario tributaries (Figure 25). It is not clear whether there is a similar pattern of improvement in the coarser bedload sediments, which are responsible for smothering stream fish habitats.

Figure 25. Suspended sediment loadings: 1972 to 1998

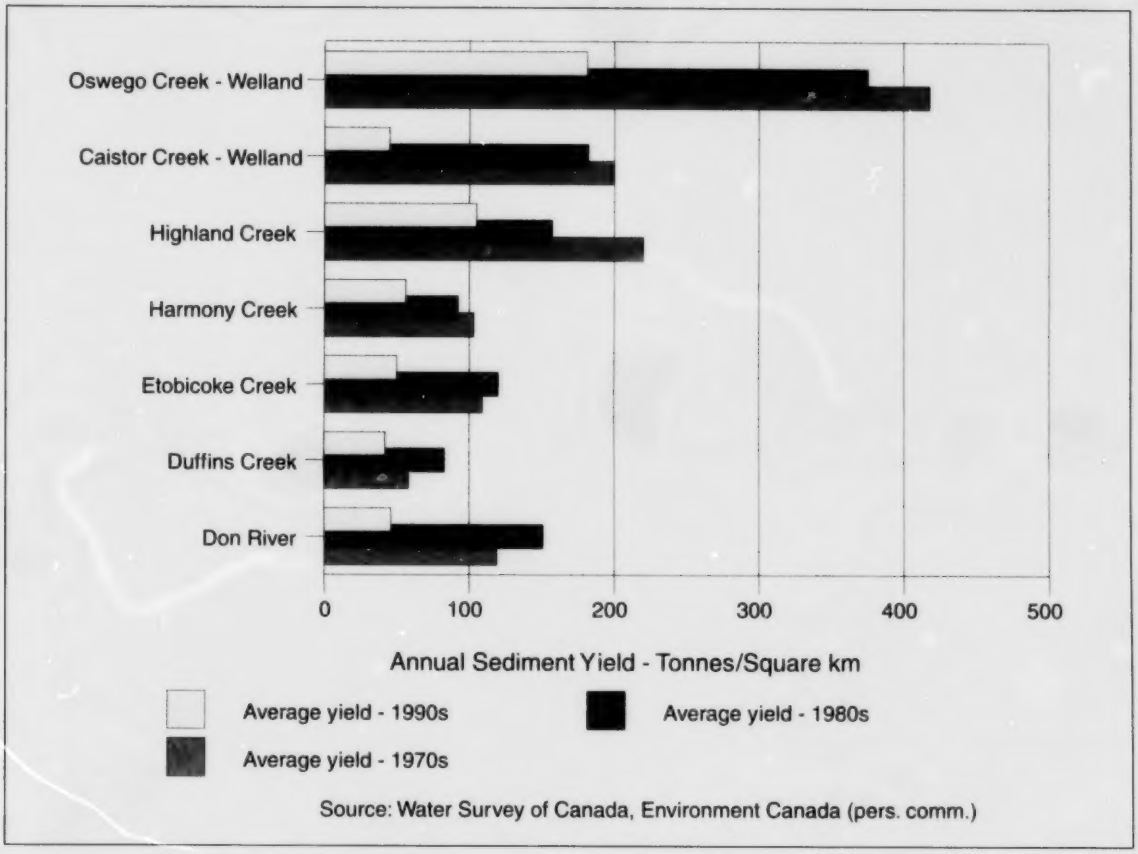


Source: Water Survey of Canada, Environment Canada (pers. comm.)

The load or amount of sediment carried by tributaries varies widely and depends both on the volume or flow of the stream as well as the yield of sediment from the watershed. Five tributaries – the Trent River, Welland River, Humber River, Don River, and Credit River – contributed over 60 percent of the 1999 total volume (load) of suspended sediment from the Canadian side of Lake Ontario.

The yield of sediment per square kilometre of watershed area indicates erodibility and gives quite a different picture. As shown on Figure 26, the top seven rivers, in terms of sediment yield per square kilometre of their watershed area, include only one (the Don River) of the five tributaries which contribute the highest volume. Each has all shown marked improvements during the 1990s. This may reflect a combination of improved agricultural and urban development practices, more benign weather, and remedial actions. However, it is worth noting for comparison that a total of 18 tributaries (including two of the five listed above) have an annual sediment yield of less than 10 tonnes/square kilometre, a small fraction of the levels for these seven highest yielding streams.

Figure 26. Tributary watershed sediment yields: 1970s to 1990s



Not all tributaries are showing such improvements. Concern has been expressed about the apparent reverse trend in suspended solids concentrations feeding into the Hamilton Harbour AOC (Gale 1999), wich could only come from an increasing sediment yield per square kilometre of watershed. Tributaries with watersheds that include large areas of urban development activities tend to experience relatively high suspended solids loadings where construction activities may have exposed tracts of bare soil.

Most toxic contaminants in the six tributaries being monitored meet Provincial Water Quality Objectives.

During 1997 and 1998, large volume sampling was carried out at six Lake Ontario tributaries, which together total about 80 percent of the tributary flow into the Lake (Boyd and Biberhofer 1999). These tributaries included the Credit River, Humber River, Ganaraska River, Trent River and Twenty Mile Creek and Twelve Mile Creek. Among the early findings of this program are:

- No samples were detected above the Provincial Water Quality Objectives (PWQOs) for chromium, mercury, mirex, HCB, benzo(a)pyrene, or any of the organochlorine pesticides.

- Total PCB concentrations were detected above the PWQO in all wet and dry weather samples. The similarity in ranges of total PCB concentrations across the range of land use types in the monitored watersheds suggests a relatively uniform background source, which may be attributed to both atmospheric deposition of PCBs and their ubiquitous presence at sites throughout the drainage basin.

- The influence of highways, urban land uses, and high population density was apparent in elevated levels of several metals at the Credit River and Humber River sampling locations, particularly during wet weather when stormwater runoff would be greater.

- Total phosphorus levels frequently exceeded the PWQO during wet weather sampling, for all tributaries except the Trent River.

A more detailed analysis of trends and status of toxins in the aquatic environment will be provided in future Lake Ontario LaMP reports.

Variability in Flow

Increased streamflow variability is associated with intensive agricultural and urban land uses within the watershed.

Increased variability in streamflow – typically very high flows during snowmelt and after rainstorms, and low flows during summer dry spells – puts great stress on the aquatic environment. High flows usually carry high concentrations of suspended solids, phosphorus, and other pollutants associated with fine particles. This stormwater scours stream bottoms and tears at streambanks, reducing the diversity of structure in the aquatic environment. During low flow periods, streams become sluggish and warm, and smaller tributaries may dry up completely (Don Watershed Regeneration Council 1997).

An analysis of flow variability among Great Lakes tributaries by Richards (1990) analyzed flow data to develop a four-level classification, from event-responsive (i.e., showing very high flows after a rain event) to superstable (for rivers showing little response to rainfall). The larger Lake Ontario tributaries have been classified according to this system as shown in Table 11.

Table 11: Flow responsiveness of Lake Ontario tributaries (from Richards 1990)

Event-responsive	Variable	Stable	Superstable
None	Spencer Creek Oakville Creek Etobicoke Creek Highland Creek Rouge River Moira River Salmon River Napanee River	Credit River Humber River Don River Duffins Creek Oshawa Creek Harmony Creek Trent River	Welland River* 12-Mile Creek*

* Note that both of these tributaries are affected by flow diversion and Ontario Power Generation activities, and their watersheds are considerably more event-responsive than this analysis indicates.

Soil type is a major factor determining the event responsiveness of streams, with highly responsive streams typically associated with fine-grained, heavy soils, and stable streams associated with looser, coarser soils with better infiltration capacity. Complex topography such as that found on the Shield, with drainage forced into tortuous patterns, can also contribute to more stable flows. Highly event-responsive streams (found elsewhere in the Great Lakes basin) are often in areas of intensive agricultural land use, and in areas of high urbanization.

A more up-to-date analysis of stream event-responsiveness for Lake Ontario tributaries would be useful, both to confirm or modify these results, and to include other significant tributaries such as the Ganaraska River and Wilmot Creek.

A related effect of more intensive land use is a rise in the total annual flow of tributary streams, since rainwater runs off impervious surfaces or bare soil relatively quickly, and goes downstream rather than being absorbed. For example, the Don River's total annual volume, measured at Todmorden Mills, doubled over the 28-year period from 1962 to 1990 (Don Watershed Regeneration Council 1997). This added flow, which takes place entirely in relation to rainfall events, adds to the sediments and other pollutants carried downstream to the Lake.

Stream baseflows and water quality are at risk from urbanization and excessive groundwater taking.

Stream baseflow – the discharge of a steady supply of cool groundwater to a stream year-round – is very important to defining aquatic habitat quality. The amount of groundwater contribution is particularly critical to maintaining brook trout populations (Bowlby and Roff 1986) and associated coldwater communities. In an examination of the Don River tributaries, the Toronto and Region Conservation Authority (1996) found that streams with a baseflow of 23 to 37 percent of the annual flow supported self-sustaining populations of coldwater fish species. Ratios of 0.9 to 9 percent supported a variety of warmwater fishes, including some considered sensitive.

In rural areas, tile drainage may intercept potential groundwater flows and direct it to streams, and the loss of forest cover and wetlands may affect recharge functions. In contrast to the

increase in total annual streamflows mentioned above, the baseflows derived from groundwater are considerably lower now than in presettlement times. Urban development is particularly damaging to stream baseflows.

Several studies have suggested that when hard surfaces associated with urban development reach 15 to 25 percent of a watershed, baseflow, runoff characteristics and water quality are impaired (Snodgrass 1992; Schueler 1994). In parts of the Lake Ontario watershed where deep permeable soils support high groundwater recharge and subsequent high baseflow to headwater streams, including most notably the Oak Ridges Moraine, the extent of urbanization that should be permitted has become a major public issue.

Urban drainage, including storm sewer systems and combined sewer overflows, create a variety of impacts on receiving waters, including:

- flow impacts, such as increased surface runoff volume and peak flow frequency;
- erosion and increased concentrations of suspended solids;
- temperature rise in streams, leading to species succession;
- increase in chloride loads;
- dissolved oxygen depletion;
- nutrient enrichment and eutrophication;
- toxic impacts from elevated levels of ammonia, chlorides, metals, hydrocarbons and trace organic contaminants; and
- public health impacts from high loads of fecal bacteria (Marsalek 1999).

During wet weather water quality studies in the Toronto area, the most frequent episodes of severe toxicity were found in stormwater samples from freeways during winter months, although up to two-thirds of all combined sewer overflow samples showed chronic toxic effects in their undiluted form (Marsalek and Rochfort 1999). The distribution of annual loadings of toxic contaminants from urban runoff in the Canadian Great Lakes basin is skewed particularly to Lake Ontario, which receives approximately 60 percent of the basin total (Marsalek and Schroeter 1988).

Human uses in non-urban areas can also greatly affect tributary waters. The Credit River ecosystem is one of the tributaries dependent on high quality baseflow from groundwater. The Credit River Fisheries Management Plan, which is nearing completion, identifies the lack of adequate management of water taking as the highest priority issue for the protection of fish habitat in the river (Credit Valley Conservation 1999a). Credit Valley Conservation points out that there has been a five-fold increase in total water demand in the watershed since 1962 and all projections show that this increase will continue. In 1999, water levels in the Credit River were at a 38-year low, and concern was being expressed that groundwater demand might be exceeding

the supply (Credit Valley Conservation 1999b). Similar concerns occur in other areas of high-quality groundwater where high demand exists for water-bottling, golf course or agricultural irrigation, or municipal water supplies.

Climate Change

Climate change will exacerbate existing stressors on aquatic ecosystems in coming years.

Climate change is expected to have considerable impact on aquatic ecosystems within the Great Lakes basin, as a result of changes in precipitation, decreased runoff, increased evapo-transpiration and decreased water levels. Volume IV of the *Canada Country Study* (Smith *et al.* 1998) suggests that climate change will compound the stresses aquatic organisms currently experience as a result of watershed modification and contamination by humans, through a number of mechanisms:

- Surface runoff to streams will decrease significantly (i.e., by an estimated 12 to 35 percent for the Grand River), and will change in its seasonal patterns (ie., increased winter floods and decreased summer streamflow).
- Rates of groundwater recharge will decrease significantly (in the order of a 15 to 35 percent reduction for the Grand River watershed), and groundwater discharge to streams will drop correspondingly (estimated at a 17 to 39 percent drop for the Grand River).
- Streamflow will decrease by an estimated 8 to 25 percent across the Great Lakes basin, with the increased possibility of winter floods and decreased summer flow. A greater variability of water levels and flows is also anticipated.
- Summer water temperatures will be warmer, causing a decrease in salmonid and percid (walleye and yellow perch) populations, and a major increase in the area occupied by warm-water communities such as bass.
- Reduced water flow may concentrate pollutants, disrupt nutrient cycling, and increase competition among aquatic organisms.
- Aquatic ecosystems may be more vulnerable to species invasion, particularly by species from the Mississippi and Atlantic coastal basins.

While the *Canada Country Study* used the Grand River as an example to illustrate these effects, they would likely be similar in Lake Ontario tributaries as well.

Aquatic Habitat Fragmentation

Dams and other barriers in tributary streams have disrupted fish movement, changed habitat conditions, and prevented genetic dispersal.

Dams and impoundments have been part of the history of Lake Ontario tributaries since shortly after the arrival of European settlers (Sly 1991). While a great many dams washed out as a result of increased flooding associated with deforestation or of abandonment after their economic purpose was gone, a substantial number still remain. One of the major effects has been to bar anadramous fish, which live most of their adult lives in the Lake but spawn in rivers, from much of their potential reproductive and nursery habitat. Very few Lake Ontario tributaries are open to lake-run fish all the way to their headwaters, as shown on Figure 24 (page 54).

These dams impact on the distribution of other fish within a catchment as well. Even small lamprey barriers have been shown to have significant effects on fish movement and fish species distribution within two Lake Ontario tributary streams (Porto *et al.* 1999).

On the other hand, some biologists argue that these barriers have effectively protected brook trout populations in headwater areas from competition from non-native species, and they should be retained (Croskery 1995). Resident brook trout populations have been dramatically reduced in areas where non-native salmonids are abundant, and former migratory populations of this species (known as coasters) are now extinct (L. Stanfield pers. comm.). Another native anadramous species, the Atlantic salmon, is now being re-introduced, but competition from non-native migratory salmonids may pose a major constraint to its success.

The largest Lake Ontario tributary, the Trent River, is a special case since it has been impounded by a series of dams and locks for navigational purposes. As a result, most of its former rapids have been submerged by ponded water, and the aquatic habitats of the river have been fragmented into a series of isolated segments. This has disrupted the dynamics and potential stability of the resident aquatic community, and has been hypothesized to prevent gene flow and dispersal among fish and other aquatic populations.

Through Trent University's Watershed Science Centre, a research project is currently underway to assess the effects of barrier systems on aquatic biodiversity in this highly fragmented setting. Preliminary results have revealed a diversity gradient with high turnover in species composition. Genetic analysis of key species will be used to assess gene flow and metapopulation dynamics along valley and river segments, to provide a better picture of the cumulative impacts of barriers and fragmentation on fish communities (Watershed Science Centre 2000).

The Welland River shows similar impacts related to dams and locks. Data collected in the Welland River watershed in 1996 and 1997 suggest that fragmentation is one of the major stressors affecting fish populations in that watershed (C. Attema pers. comm.).

3.5 Summary of Impairment, Information Gaps, and Emerging Issues

- Habitats within Lake Ontario tributary streams are significantly degraded, both in their riparian cover and their fish communities. While much of this degradation is long-standing, dating from the early European settlement period, habitat conditions are improving very slowly.

- Loadings of sediments and other pollutants to tributary waters have declined significantly over the past two decades, with suspended and bedload sediments, phosphorus, and PCBs remaining as the most widespread pollutants. Trends in bacterial loadings were not examined in this report.

- Intensive agriculture, urban development, and groundwater taking are causing increased streamflow variability and lower baseflows in some areas, which threaten the health of aquatic communities.

- Dams and barriers have fragmented and modified stream habitats, and continue to bar lake-run fish from many sections of stream, with both positive and negative results.

- Climate change will exacerbate many of the existing impairments in tributary waters, and poses an enormous challenge to the health of aquatic communities in the watershed.

- The development and application of a consistent, hierarchical aquatic habitat classification system to the streams of the watershed would be a major step forward in identifying priorities for protection and management. Tools that predict fish community and habitat conditions for each river segment will enable more informed and quantitative decisions about resources management and potential impacts of development.

- A much improved information and research base is needed on groundwater hydrology and threats, together with significantly stronger steps to protect critical groundwater resources such as the Oak Ridges Moraine. Additional research on stormwater management technologies and planning approaches to minimize urban stormwater impacts would also be beneficial.

- New techniques are needed to prevent or remediate aquatic habitat impacts from urban development, and to promote the implementation of known techniques such as riparian buffers, stormwater retrofit work, and Best Management Practices.

4.0 Nearshore Lands and Waters

4.1 Habitat Characteristics and Historical Changes

The Lake Ontario shoreline, where the land and lake interact, is a dynamic and productive part of the ecosystem. Its mosaic of shoreline features, wetlands, and shallow waters attracts fish, migratory birds, and other wildlife for key stages of their life cycle. For the past 200 years, it has also attracted intensive human use, often setting up conflicts with natural processes. For instance, regulation of Lake Ontario water levels for hydropower, commercial navigation and shoreline property owners, has had significant environmental impacts on the shoreline, especially coastal wetlands.

The width of nearshore lands and waters is based on ecological characteristics. The bottom of Lake Ontario generally is smooth and relatively steeply sloping into deeper waters, although less so on the north shore of the Lake. The SOLEC '96 background paper on *Nearshore Waters of the Great Lakes* (Edsall and Charlton 1996) defined nearshore waters as the area extending outwards to the deepest lake-bed contour where the thermocline typically intersects with the lake bed in late summer or early fall. For Lake Ontario, this can be as deep as 30 metres. Nearshore terrestrial ecosystems include landforms and biological communities (such as dunes and bluffs) that are products of the influence of the lakes (Reid and Holland 1997). In most cases, these features are located within one to two kilometres of the current shoreline.

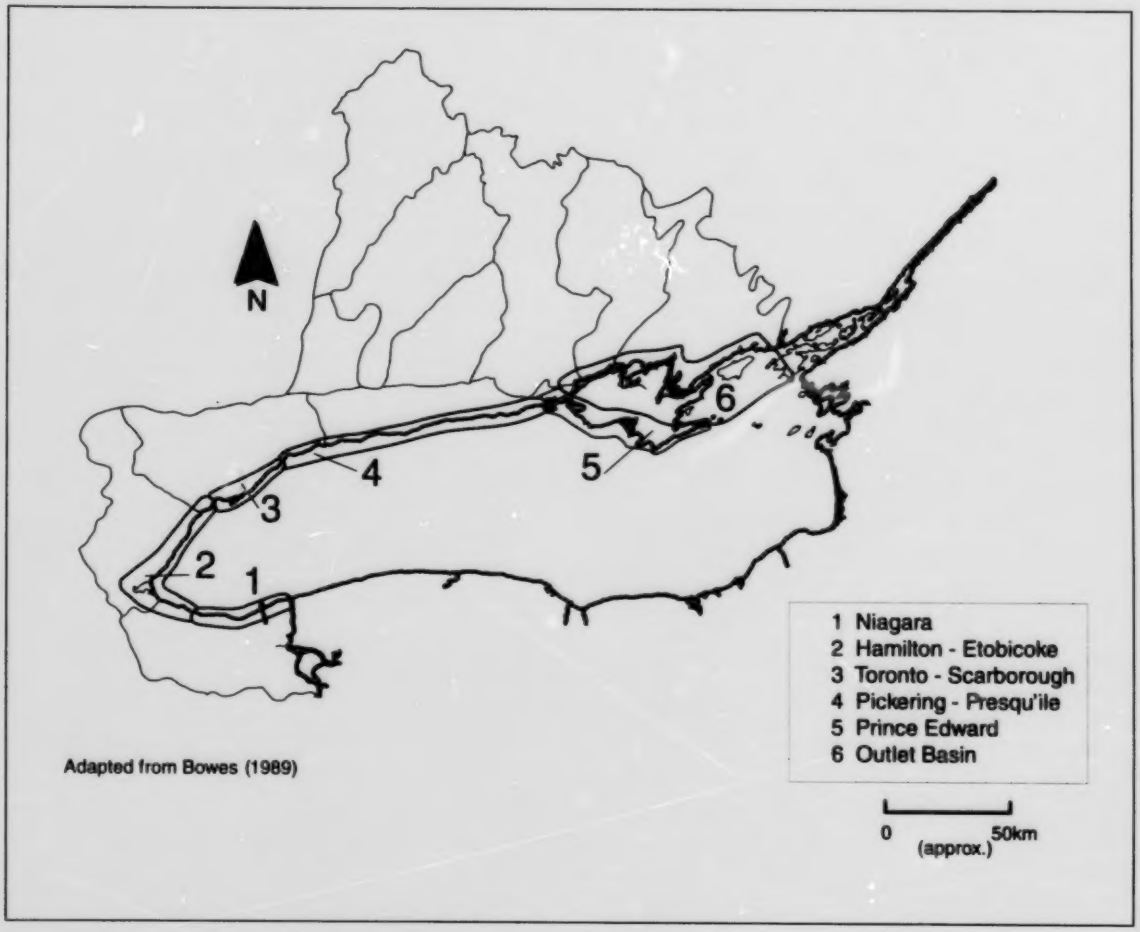
The nearshore zone along the Canadian coast of Lake Ontario shows considerable variation. For example, while most of the coast is relatively straight and without islands, dropping off smoothly to deeper water, the Outlet basin is much shallower and more complex. Although this basin occupies less than 20 percent of the Lake's area, it has 50 percent of the total shoreline length (Croskery 1995). At a general level, a series of six shore zones, modified from Bowes (1989) provides a good description of the variability, as outlined in Figure 27 and Table 12.

More detailed mapping of shoreline reaches has been carried out for Lake Ontario, subdividing the shoreline into 468 reaches (Geomatics International 1992). For the north shore from Hamilton to Trenton, the Waterfront Regeneration Trust has characterized shoreline profiles, aquatic habitats, and shoreline terrestrial habitats (Waterfront Regeneration Trust 1995a, 1996). Mapping of nearshore bottom sediments, along with information on sediment sources and movements, has been carried out by Rukavina (1969, 1970) and St. Jacques and Rukavina (1972). The dynamic nature of nearshore sediments is demonstrated by a comparison of the Wellington Bay area from 1915 to 1916 and 1970 to 1971, which shows an increase in the areal extent of underwater sand bodies by about 40 percent. While the mechanisms for supplying recent sediments in the nearshore zone include bluff erosion, bottom erosion, stream discharge, and littoral drift, in this instance most of the accrued sediment is thought to have arrived from more westerly areas through littoral drift (St. Jacques and Rukavina 1972).

The major characteristic that determines the evolution of the shoreline over the long term and at a large scale is the "controlling substrate", which is defined as the material that makes up the main body of the nearshore lakebed (Waterfront Regeneration Trust 1996). The Lake Ontario shore is dominated by erodible limestone and shale bedrock and by cohesive till or clay materials. These substances are subject to irreversible erosion or downcutting from wave

action. Most of the shoreline has a "convex profile" i.e., the nearshore lakebed features a shallow shelf for several hundred metres offshore before dropping to deeper waters. Where the shoreline is made up of fine-textured clays, as in the Scarborough Bluffs, the profile is concave, dropping steeply to deep water immediately offshore.

Figure 26. Lake Ontario Canadian shore zones



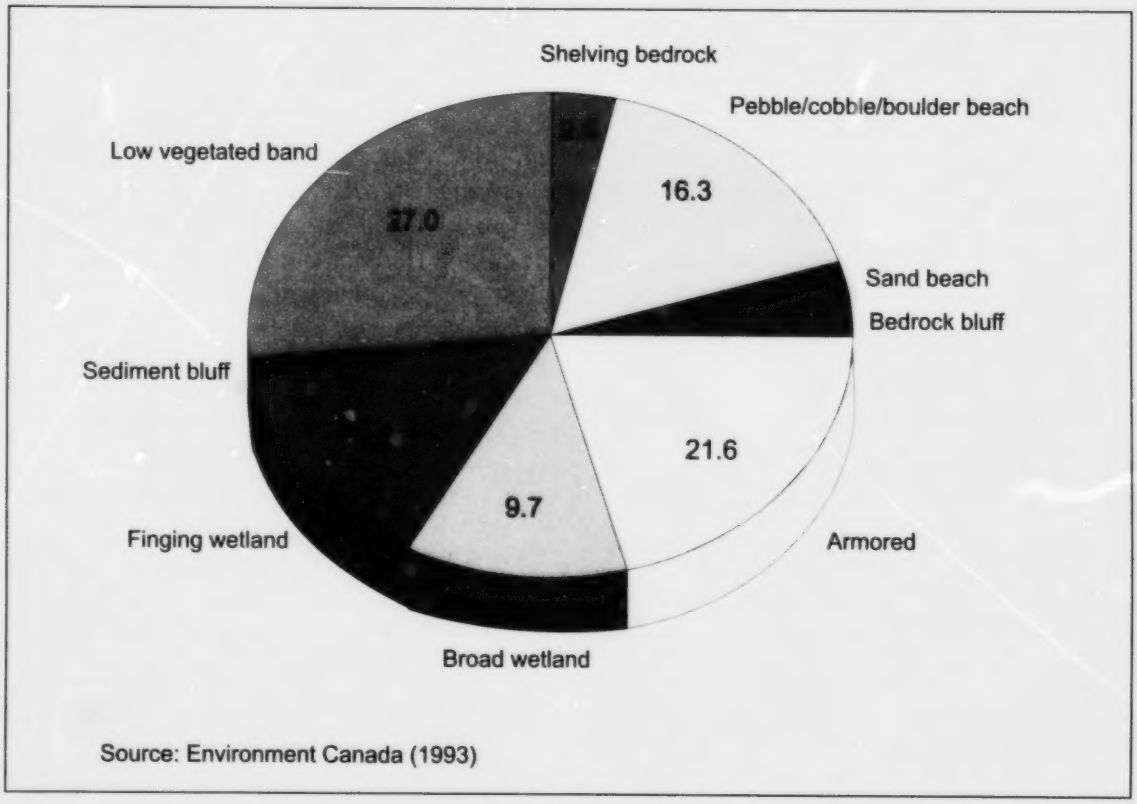
The third controlling substrate along the Lake Ontario shore is deep sandy dynamic beach, such as those found at Burlington Beach (near Hamilton) and Presqu'ile (near Brighton). These beaches are often recipients of sediments eroded from elsewhere along the shore. They can erode temporarily during storm events, but over time wave action will rebuild their reservoir of sand.

Table 12: Shore zone characteristics of Lake Ontario: Niagara to Kingston

Zone	Coastal Character (Bowes 1989)	Controlling Substrate (Nairn 1995; Waterfront Regeneration Trust 1996)	Sediment Character (Rukavina 1969, 1970; St. Jacques and Rukavina 1972)	On-shore Character (Waterfront Regeneration Trust 1995b)
1 Niagara	Low-relief cliffs, straight coast, narrow beaches; barrier beach wetlands at Fifteen and Sixteen Mile Creeks	Erodible shale and cohesive till with convex profile	Mostly silt-clay sediments, with patches of glacial till and shale bedrock; large sand-gravel bar across mouth of Niagara River; net drift to the west	Agricultural, urban, remnant tree cover in valleys
2 Hamilton-Etobicoke	Low relief, straight coast, beaches absent except in Burlington baymouth bar	Mostly erodible shale with convex profile; dynamic sand beach at Burlington; some concave cohesive shore along Stoney Creek-Grimsby area	Sediment movement to the west, but limited by shore structures; silt and sand sediments accumulate in Burlington bar area	Largely urban, with most shoreline hardened; few forest and wetland remnants
3 Toronto-Scarborough	Scarborough Bluffs rise 107 m above Lake; recurved spit around Toronto Harbour	Unconsolidated sand with convex profile; fine-grained till with concave profile along Bluffs; river valley buried in silt at Humber Bay	Sand deposits off eastern sections, silts in west; sediment movement to west but highly disrupted by lakefill and shore hardening	Highly urban with only remnant pockets of wetland or forest; most shoreline areas hardened.
4 Pickering-Presqu'ile	Straight coast with mostly low relief shorebluffs, narrow beaches; one area of higher clay bluffs	Cohesive cobble-boulder till with limestone bedrock in eastern half; convex profile	Sediment movement to the east, glacial sediments and lag deposits, some bedrock and frequent boulders; sand accumulation around Presqu'ile	Urbanized in west, agriculture and forest increasing in east; estuarine and barrier beach wetlands
5 Prince Edward	Low bedrock plain forming points, baymouth bars and beaches	Limestone bedrock as controlling substrate; dynamic pocket beaches; convex profile	Offshore sand deposits in Wellington Bay; exposed bedrock lakebed in most of area; sediment movement to the east	Agriculture and forest; extensive wetlands in sheltered bays
6 Outlet Basin	Complex coast of low relief bedrock outcrops, bays, beaches, and islands	Limestone bedrock inferred as controlling substrate, with dynamic sand beaches	Little sediment transport; mostly limestone bedrock lakebed, silts in sheltered bays	Agriculture and forest; extensive wetlands in sheltered bays

The distribution of habitats immediately along the shoreline has been classified and mapped in detail in an atlas designed to ensure a timely response to spills (Environment Canada 1993). This information provides an overview of the kinds and frequency of various habitat types (Figure 28).

Figure 28. Percent of shoreline habitats: Lake Ontario Canadian shoreline



Source: Environment Canada (1993)

The Shoreline Management Work Group of the Waterfront Regeneration Trust identified four main types of aquatic nearshore habitats on the north shore of Lake Ontario, with these habitats closely linked to their physical classification of shoreline types:

- Sandy dynamic beaches are used by relatively few species because their surficial substrate is always moving, providing a poor base for aquatic plants or other organisms. These habitats may provide suitable spawning and rearing habitat for some fish species including lake herring, emerald shiners, alewife and smelt.

- Erodible bedrock or boulder till habitats develop a convex profile with a nearshore shelf that has a minimal presence of sand and a steep drop-off to adjacent deeper waters. This combination may be important to spawning lake trout or lake whitefish, while surface crevices and coarse substrates provide suitable surfaces for the attachment of eggs.

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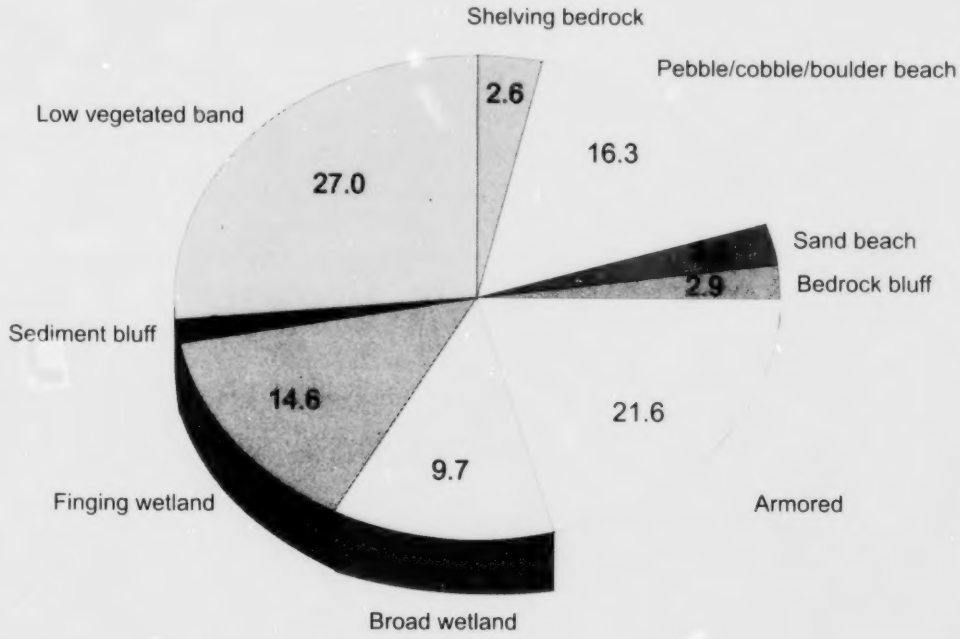

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- Cohesive fine-grained tills with a concave profile have high turbidity levels and mobile sediments. Similar to sandy dynamic beaches, a relatively few number of species use this habitat.

- Sheltered embayments and river mouths offer warmer, sheltered waters where vegetation can become established, often forming wetland habitats. The more varied thermal conditions allow for the development of a more diverse aquatic environment, including warm-water species such as pike and bass (Waterfront Regeneration Trust 1996).

In their aquatic community classification framework, The Nature Conservancy (TNC) also started with combinations of shoreline geomorphology and sub-aqueous substrate to define habitats (Higgins *et al.* 1998). Nearshore zones are subdivided to recognize major areas with differing thermal and nutrient conditions, such as Hamilton Harbour and Bay of Quinte. Since substrate composition is correlated with benthic invertebrate distributions and both adult and young-of-the-year fishes, this factor is used as a major determinant in defining habitat classes. Application of the TNC approach to Canadian sections of the Great Lakes has yet to take place.

Many of the nearshore habitats in Lake Ontario are poorer in quality and diversity now than they were at the time of European settlement. Several main factors have affected habitats adversely:

- Along the western part of the lake nearshore, a great quantity of boulders, which likely were productive spawning shoals, have been removed through the historic practice of stonehooking for building materials.

- Near built-up areas, large quantities of fine sediments have been deposited over native sediments; often this fine sediment was associated with contaminants or high levels of nutrients which further altered habitat conditions.

- In urban areas, nearshore areas and wetland habitats have been converted to dry land for housing or industrial purposes, including the loss of the Ashbridge's Bay Marsh at the mouth of the Don River in the early 1900s.

- Numerous small scale projects to protect the shoreline from erosion have resulted in long stretches of altered coast, which disrupt natural sediment transport processes and result in the loss of shoreline habitats.

- Tributary and stream mouth areas have often been altered for portland or other purposes, and degraded by sediments and nutrients flowing down from their watersheds.

- Dams and barriers in tributary streams have cut off traditional spawning and nursery areas from many species of Lake Ontario fish (Waterfront Regeneration Trust 1996).

4.2 Defined Habitat Goals for Nearshore Lands and Waters

The *Lake Ontario Greenway Strategy,* released in 1995, included a number of specific objectives and actions related to both terrestrial and nearshore aquatic habitats in the shoreline area from Burlington to Trenton (Waterfront Regeneration Trust 1995b). These include:

Protect the physical, natural and cultural attributes associated with the Lake Ontario Greenway:

- protect significant coastal features and habitats through Integrated Shoreline Management Plans, including protection of open wave-washed coast with convex bedrock or cobble boulder substrates, existing warmwater fish habitats, connecting habitats, and significant coastal features such as dunes, bluffs and shale exposures;

- protect 90 waterfront natural core areas through planning designations, stewardship, and acquisition;

- protect 35 valleys identified as bioregional habitat corridors, together with other landscape connections such as the Lake Iroquois shoreline corridor and the nearshore littoral zone; and

- protect water quality from further deterioration through watershed and subwatershed plans, continued efforts to reduce sediment and pollutant loadings, and integrated monitoring programs.

Identify rehabilitation needs and methods and encourage landowners, communities and agencies to undertake regeneration activities:

- restore the supply of natural habitats that sustain biodiversity, by increasing natural vegetation in lower sections of major tributary valleys to 50 percent cover and in urban areas to 10 percent cover, and by seeking no net loss of forest cover in rural landscapes;

- protect or restore an additional 850 hectares of wetland habitats within the Greenway within five years;

- target rehabilitation programs to priority habitats, including large blocks of forest and marsh habitat, shoreline and estuarine wetlands, habitat linkages within corridors, specialized Great Lakes shoreline habitats, and other specialized habitats that enhance biodiversity, such as sites for threatened species;

- target warmwater fish rehabilitation programs to the central waterfront around Toronto;

- encourage larger rehabilitation nodes rather than scattered small projects, and incorporate rehabilitation into trail development projects and valley corridor rehabilitation plans;

- restore natural shoreline structure and processes through Integrated Shoreline Management Plans and innovative treatments to naturalize shorelines; and

- restore degraded waters and sediments through federal-provincial agreements, continued progress on Remedial Action Plans (RAPs), development of the Lakewide Management Plan (LaMP), and encouragement of watershed rehabilitation strategies.

In addition, some of the current RAP programs include specific objectives related to nearshore habitats. For example, the Toronto and Region RAP has proposed targets of re-establishing 10 to 20 hectares of waterfront marsh by the year 2000, and 65 to 75 hectares by the year 2010. As well, the construction of two kilometres of open coast reef habitat by the year 2020 is proposed (Waterfront Regeneration Trust 1995b). Goals for the Hamilton Harbour RAP include increasing fish habitat in the harbour by 372 hectares and wildlife habitat by 299 hectares, as well as increasing littoral habitat by 16 kilometres (Gale 1999).

Nearshore fish community objectives have been established through the recent development of a binational document called *Fish-Community Objectives for Lake Ontario* (Stewart *et al.* 1999) which recommends:

The nearshore fish community will be composed of a diversity of self-sustaining native fish species characterized by:

- maintenance of existing walleye populations and expansion of walleye populations into favorable habitats;

- maintenance of existing yellow perch populations and expansion of yellow perch populations into favorable habitats;

- a population recovery of the lake sturgeon sufficient for its removal from New York's list of threatened species;

- population levels of smallmouth bass, largemouth bass, and sunfishes attractive to anglers; and

- increasing numbers of American eels consistent with global efforts for their rehabilitation.

4.3 Current Status and Recent Trends

Terrestrial Shoreline Habitats

Terrestrial habitats in a natural state are in very limited supply along the shoreline and are declining further.

Lake Ontario shoreline habitats incorporate a series of significant ecological values:

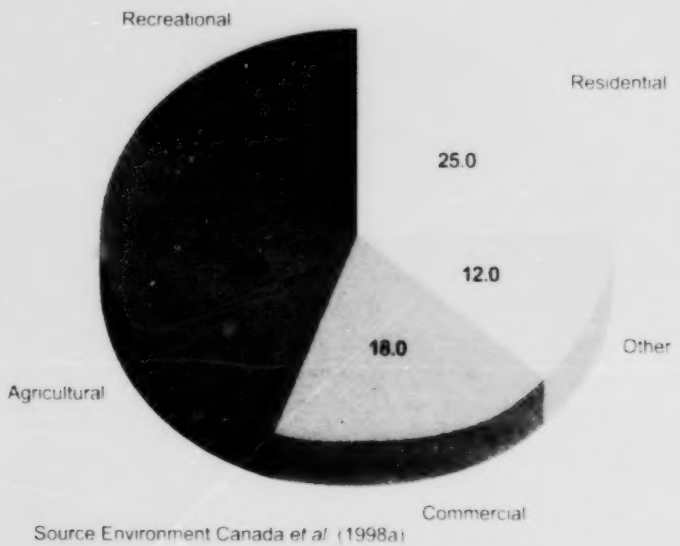
- specialized landforms and natural communities (such as beaches, dunes, shorecliffs) associated with current and previous Great Lakes shorelines;
- habitats for a large diversity of species, including over 1 500 species of vascular plants, 165 breeding species of birds, 47 mammal species, 34 species of reptiles and amphibians, as well as hundreds of species of insects and other invertebrates;
- significant staging and wintering areas for a large number of species of migratory birds and butterflies, particularly during the spring migration when the arrival of migrant songbirds coincides with the first hatch of midges along the shore; and
- ecological buffers, linkages, and source areas for species and genetic interchange and replenishment (Waterfront Regeneration Trust 1995a).

However, a quick look at shoreline land use shows that forest and other natural habitats occupy only a small part of their former extent, so reduced as to be lumped into the "other" category (Figure 29).

Terrestrial habitats in short supply in the nearshore zone have been identified in the *Natural Heritage Strategy for the Lake Ontario Greenway* (Waterfront Regeneration Trust 1995a), which looked at the landscapes along the waterfront in 17 landscape units, each of which shares similar landforms and patterns of forest cover. Habitats in short supply include:

- forest cover, which only exceeds 10 percent in six of the 17 landscape units;
- lower valley corridors – most now have natural cover in the four to 10 percent range, far short of the 50 percent recommended target;
- natural vegetation in urban areas which now ranges from 0.4 to five percent, short of the 10 percent recommended target (Waterfront Regeneration Trust 1995a); and
- interior forest habitats – none of the 17 landscape units have more than one percent interior forest; 11 of the units have none at all.

Figure 29. Percent of Lake Ontario shoreline land use (Canadian side only)



Source Environment Canada *et al.* (1998a)

Breeding birds provide another useful indicator of the supply and health of terrestrial habitats. The western section of the Lake Ontario shoreline falls within a physiographic region having the highest relative abundance of breeding birds in the Great Lakes and surrounding region (Mac *et al.* 1998). However, this area is showing negative trends for grassland birds, shrubland and old field birds, and short-distance migrant birds. Woodland birds are also showing negative trends, but in a smaller section of the Lake Ontario north shore. Towards the eastern end of the Lake, the trends in bird populations are more uniformly positive, except for grassland birds (Peterjohn *et al.* 1995).

Many occurrences of special lakeshore natural communities lack long-term protection from alteration.

Significant habitats or specialized communities associated with the lakeshore have been identified through a series of reports and studies, as summarized in Table 13. In some cases, an assessment of the protection (i.e., a formal mechanism in place to prevent the loss or serious impairment of ecological values such as public ownership and formal planning designations) status of various natural features has also been prepared, and these are discussed below in more detail.

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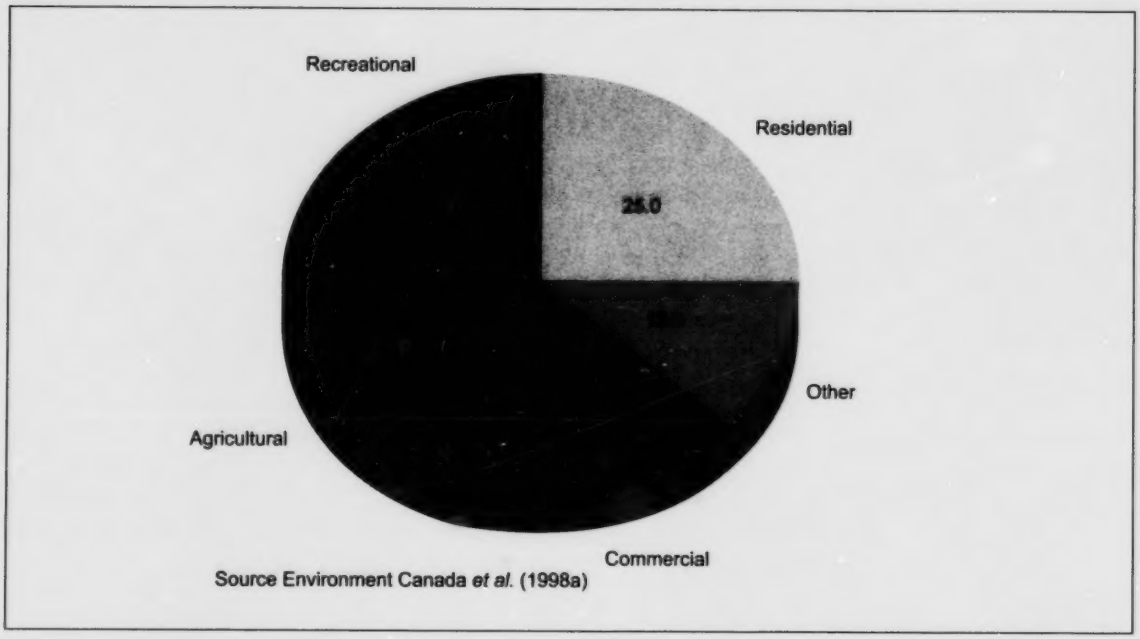

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Table 13: Summary of special lakeshore natural features and designations

Special Natural Features	Information Source
Sites of special natural heritage interest	*Towards the Protection of Great Lakes Natural Heritage Areas* (Smith 1987)
Special geomorphological features	*Review of the Geomorphological Diversity of the Great Lakes Shore Zone in Canada* (Bowes 1989)
Environmentally sensitive shoreline areas	*Environmental Sensitivity Atlas for Lake Ontario's Canadian Shoreline* (Environment Canada 1993)
Terrestrial Biodiversity Investment Areas	*Biodiversity Investment Areas - Nearshore Terrestrial Ecosystems, Version 3* (Reid *et al.* 1999)
Wetland ecoreaches	*Biodiversity Investment Areas - Coastal Wetland Ecosystems* (Chow-Fraser and Albert 1998)
Coastal wetlands	*Coastal Wetlands: Working Paper for SOLEC 1996* (Maynard and Wilcox 1996); *Ontario Coastal Wetland Atlas* (Ontario Ministry of Natural Resources and Environment Canada, in press)
Twelve special lakeshore communities	*The Land by the Lakes: Nearshore Terrestrial Ecosystems* (Reid and Holland 1997)
Natural heritage core areas	*Waterfront Natural Areas (Brownell 1993); A Natural Heritage Strategy for the Lake Ontario Greenway* (Waterfront Regeneration Trust 1995a)

A suite of twelve special lakeshore communities, defined as places along the shore having unique physical features and habitats supporting biodiversity, unique plant and animal life directly dependent on lake processes, were identified by the State of the Lakes Ecosystem Conference (SOLEC) in 1996 (Reid and Holland 1997). Additional sites of special natural heritage interest have been identified by Smith (1987). Special geomorphological features were identified and mapped by Bowes (1989). Among these special communities and features which occur on the Canadian shore of Lake Ontario are:

- Sand beaches: isolated examples at Burlington, Toronto Island, Presqu'ile, all largely protected; frequent on west-facing bays on Prince Edward County and islands in the Outlet basin, but mostly unprotected.

- Sand dunes: at least six major sites, all from Presqu'ile eastwards in exposed settings. Most are protected in parks or other public ownership (Davidson 1990).

- Cobble beaches: frequent on exposed shores in eastern sections of the Lake; only a few small sections protected.

- Shelving limestone beaches: frequent examples in eastern sections of the Lake, especially in Prince Edward County; only a few sections protected.

- Limestone bedrock bluffs: a few examples, all in Prince Edward County; none protected.

- Unconsolidated shore bluffs: two examples, at Scarborough Bluffs (mostly protected although threatened by toe armouring) and Bond Head Bluffs (unprotected).

- Lakeshore drumlins: examples at Hay Bay, Adolphus Reach, Mohawk Bay, Muscote Bay, West Lake; none protected.

- Drowned river mouths: good examples at Salmon River, Humber River, Jordan Harbour, Twelve Mile Creek; partial protection but most highly modified.

- Island clusters: a mosaic of large and small limestone-based islands within the Outlet basin; a few small islands protected.

The importance of Great Lakes islands as globally-significant ecological resources was highlighted at a 1998 workshop convened by the "U.S.-Canada Great Lakes Islands Project". Among the values identified at the workshop were:

- islands as reservoirs of biodiversity * Michigan's 600 islands are only one thousandth of the state's area, but hold one tenth of their rare, threatened or endangered species;

- high importance to five species of colonial nesting birds, and medium importance to five additional species;

- special importance to migrating neotropical birds;

- valuable sites for studying environmental change due to their relative undisturbed state; and

- habitats for concentrations of Great Lakes endemic plants (Vigmostad 1998).

Of the 90 natural core areas identified in the Lake Ontario Greenway Strategy, most of which are based on a comprehensive review of terrestrial natural habitats in the area (Brownell 1993), 47 are totally or largely in public ownership, 42 have been classed as provincially significant wetlands or Areas of Natural and Scientific Interest (ANSIs), and 64 are included in some form of protective designation within local Official Plans (Waterfront Regeneration Trust 1995b). Since these designations overlap, it appears that about half of the significant core habitats have relatively good protection, with approximately another third having partial protection.

Coastal Wetlands

A majority of shoreline wetlands have been destroyed by past human activities, and remaining wetlands are threatened by habitat alteration, water level controls, and sedimentation.

Coastal wetlands along Lake Ontario are primarily submergent and emergent marshes, with some wooded swamps and a few rare coastal meadow marsh communities (Maynard and Wilcox 1996). Among their significant features are:

- habitat for 68 species of fish, of which two-thirds are permanent residents (Stephenson 1990; Jude and Pappas 1992);
- feeding, nesting and migration habitat for many species of birds, including songbirds, raptors, and waterfowl;
- breeding habitat for a diversity of wildlife, including nine bird, two reptile, one amphibian, three fish, and two butterfly species considered significant because of their rarity (Ontario Ministry of Natural Resources and Environment Canada in press); and
- habitat for 20 rare species of vascular plants (Ontario Ministry of Natural Resources and Environment Canada in press).

Historic losses of coastal wetland habitat to urban and agricultural encroachment have been severe, particularly along the western section of the Lake and in the Bay of Quinte (McCullough 1982; Whillans 1982; Ontario Ministry of the Environment *et al.* 1990). These losses can be compared to estimates of remaining wetland area (Table 14).

Table 14: Historic coastal wetland losses along the Lake Ontario shoreline

	Estimated Percent Loss to 1979	Remaining Wetland* (hectares)
Niagara to Toronto	74	523.1
Toronto to Presqu'ile	32	964.6
Presqu'ile to Prince Edward Point	8	3 076.2
Bay of Quinte	68	5 597.1
Outlet Basin	unknown	764.5

* Based on Ontario Ministry of Natural Resources evaluations performed in the mid-1980s
Source: Ontario Ministry of Natural Resources and Environment Canada in press

In recent years, the rate of wetland loss appears to have slowed, and some coastal wetlands have been restored. For example, in the Bay of Quinte, wetland loss between 1967 and 1982 was estimated to be 412 hectares, but 542 hectares was reclaimed from agriculture and restored to wetland (Maynard and Wilcox 1996).

Several factors are identified by Maynard and Wilcox (1996) as ongoing threats to Lake Ontario wetlands. Urban and agricultural encroachment continues to be a concern. Dominant plants in coastal wetlands are often invasive and include both exotic and native species. Invasive species proliferate, in part, because of the effects of water level regulation on Lake Ontario decreasing the natural fluctuations that sustain marshes. High sediment loads and excess turbidity negatively affect such wetlands as Cootes Paradise, Oshawa Second Marsh, and those in the Bay of Quinte. While sources are largely related to urban and agricultural land uses, the action of carp and wind-fetch within wetland areas are also factors (Chow-Fraser 1999). Excess nutrients have also caused the eutrophication of wetland communities, especially in the Bay of Quinte (Crowder and Bristow 1986b). Some wetlands have contaminated sediments or bioaccumulation problems in their biota (Crowder *et al.* 1989a,b; Bishop *et al.* 1995).

In combination, these stressors result in most of the remaining coastal wetland habitats being significantly impaired, with the degree of impairment generally most pronounced in the western sections of the Lake.

Coastal Birds

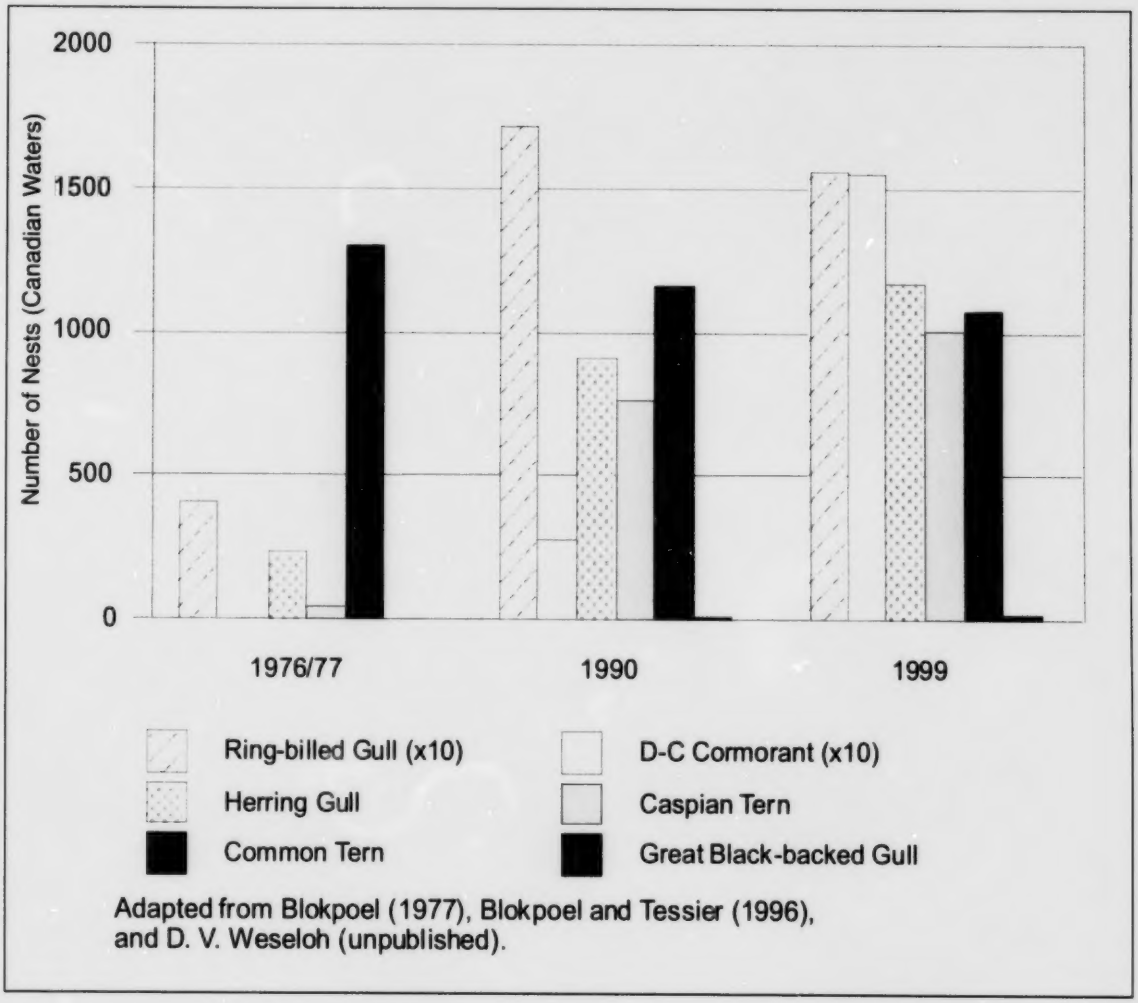
Populations of most colonial nesting waterbirds have increased, in some species dramatically, as contaminant loads have dropped.

Six species of colonial nesting waterbirds are monitored approximately every ten years on Lake Ontario. As shown in Figure 30, populations of most species have increased significantly since the mid-1970s. This increase is thought to be related to a decline in contaminant levels during the same time period, since elevated levels of contaminants in eggs were found to cause eggshell thinning, increased mortality of embryos, and in some cases deformities. Most of these conditions have improved greatly, and reproductive success has also improved as a result (Weseloh 2000).

While the number of ring-billed gulls has declined slightly from their 1990 high numbers, the only species being monitored and showing a consistent decline is the common tern. This decline appears to be related to habitat loss, disturbance through human development, and competition with early-nesting gulls (Courtney and Blokpoel 1983). Between 1990 and 1998, this species increased the number of their nesting sites on the Canadian side of Lake Ontario from six to seventeen (even though overall populations declined), with sixteen new sites being on man-made sites (i.e., peninsula, islands, shoals, or "tern rafts") and one site situated on a natural island (C. Pekarik unpublished). The success of these artificial structures suggests that additional rafts should be placed judiciously in areas where common tern populations could be increased.

Cormorant numbers continue to rise very quickly, although at a slower percentage growth rate than in the past. Over-abundance of double-crested cormorants may be a problem for other colonial species, especially black-crowned night-herons and great blue herons, and may also damage vegetation on nesting islands. Careful monitoring of their numbers and continued research on their effects on fisheries is required.

Figure 30. Number of gull, tern and cormorant nests: Lake Ontario Canadian colonies



Adapted from Blokpoel (1977), Blokpoel and Tessier (1996), and D. V. Weseloh (unpublished).

Although the increase in great black-backed gulls is small, this species is a significant predator of other species and capable of exerting considerable negative influence. Their population numbers in Lake Ontario should be carefully tracked.

While suitable nesting habitat for ospreys and bald eagles exists in the eastern section of the shoreline, widespread nesting has not yet resumed.

At various times, bald eagles and ospreys, both fish-eating raptors, have nested within the Lake Ontario basin. It is probable that osprey are most suited to the environment along the Lake, and will be the first to return (Croskery 1995). Osprey nest platforms have been erected at a number of locations along the lakeshore. However, despite good populations of ospreys in the upper reaches of the watershed, especially in the Kawartha Lakes area, only a few recent nestings have been recorded along the Lake Ontario shore in the Bay of Quinte area (T. Sprague pers. comm.).

Over the past several years, bald eagle nestings have been recorded in eight New York State tributaries to Lake Ontario, and the number of nests along the Lake Erie shore is rising steadily (Bowerman 1993). However, they have not yet returned to breed along the shores or on the islands of the Canadian side of Lake Ontario, a former stronghold. The reasons for this lack of response are not known.

Shoreline mapping of potential habitats for bald eagle nesting identified 7.8 percent of the Lake Ontario coast as having good potential, and another 42.8 percent as marginal potential, which is slightly better than Lake Erie (Bowerman 1993). Most of the good potential habitat is along the southern coast of Prince Edward County and on the islands of the Outlet basin, with pockets of marginal potential westward along the shore to the Oshawa area.

Seasonal waterfowl use along the shore has changed, generally increasing likely in response to zebra mussel populations.

The nearshore waters of Lake Ontario are an important spring and fall staging area for migrating waterfowl, particularly the areas around the outlet of the Lake and Wolfe Island (Dennis and Chandler 1974; Ross 1984; Dennis *et al.* 1984; Ross 1989). This use varies considerably along different sections of shoreline (Figure 31).

From the Niagara River mouth to Hamilton, the most notable use is by fall concentrations of greater and lesser scaup. The Hamilton to Oshawa area hosts concentrations of dabbling and diving ducks and Canada geese in both spring and fall, and is experiencing growing numbers of geese and scaup. The coastline from Darlington to Presqu'ile has relatively light waterfowl use, while the area from Presqu'ile eastwards, below Prince Edward County, has increasing concentrations of diving ducks in both fall and winter. The waters around Wolfe and Amherst islands are particularly significant (Ross 1989).

The Bay of Quinte area in the 1970s showed an anomalous lack of waterfowl, in contrast to historical observations, which Ross (1984) attributed to deteriorating habitat as a result of eutrophication. By 1989, fall use of this area showed substantial increases. In recent years, some parts of the Bay of Quinte such as Muscote Bay are showing a rapid escalation in fall waterfowl use (K. Ross pers. comm.).

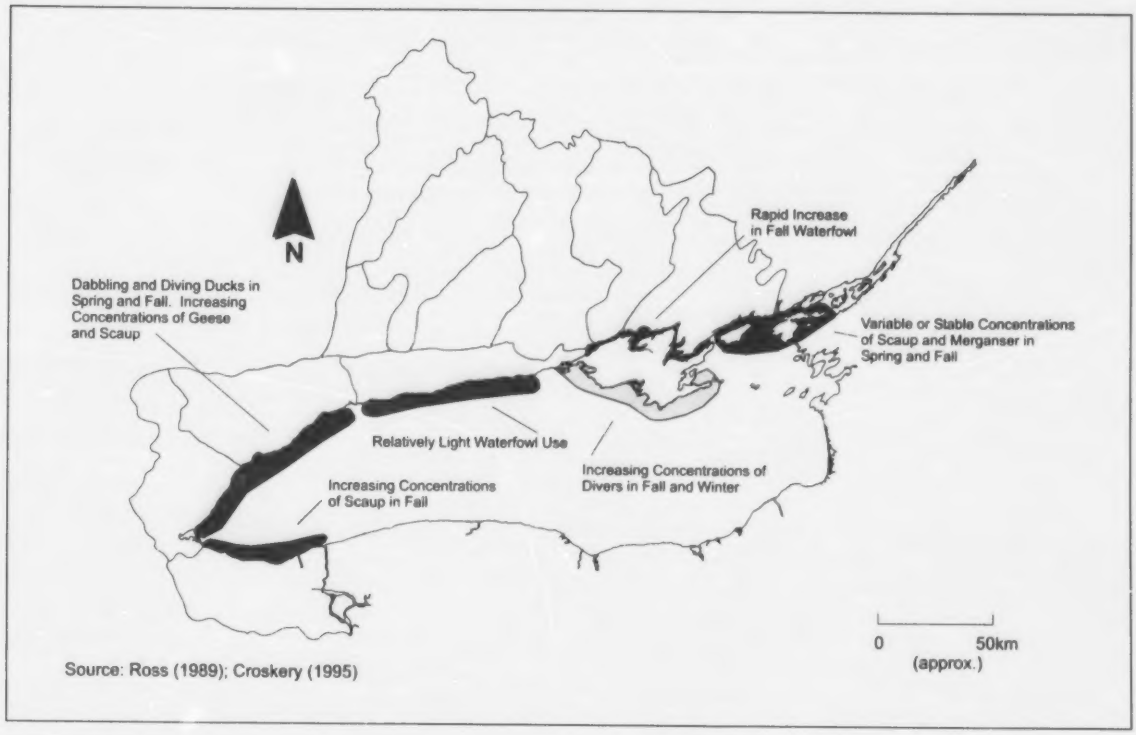
During the early 1990s, the use of Lake Ontario's offshore waters by diving ducks has been steadily increasing, with noticeable changes in species, numbers, and duration of fall stopovers (Croskery 1995). Several trends have been noted:

- In the eastern end of the Lake, particularly off Prince Edward Point, white-winged scoters, oldsquaw, goldeneye and redheads are increasing in their fall numbers and staying much longer.

- Scaup numbers have been variable with no clear trend in eastern Lake Ontario, and have increased in the western part of the Lake and in Lake Erie.

- The number of over-wintering waterfowl has increased significantly in eastern Lake Ontario, in the Hamilton and Niagara River areas, and elsewhere. The number of overwintering birds along the north shore of the Lake has increased from a 1970 to 1990 average of 18 000 to an average of 32 000 in the 1991 to 1995 period.

Figure 31. Trends in waterfowl use of Lake Ontario Canadian nearshore waters


N
Rapid Increase in Fall Waterfowl
Dabbling and Diving Ducks in Spring and Fall. Increasing Concentrations of Geese and Scaup
Variable or Stable Concentrations of Scaup and Merganser in Spring and Fall
Relatively Light Waterfowl Use
Increasing Concentrations of Divers in Fall and Winter
Increasing Concentrations of Scaup in Fall
0
50km
(approx.)
Source: Ross (1989); Croskery (1995)

Croskery (1995) and other observers believe that these changes are closely linked to the invasion of zebra mussels into the Lake. Wormington and Leach (1992) documented zebra mussels in the digestive tracts of several species of diving ducks, and identified changes in diving waterfowl numbers and distribution in western Lake Erie in relation to zebra mussels. More recently, a study on the rapid increase and subsequent decline in populations of zebra and quagga mussels in Lake Erie's Long Point Bay suggests that high rates of waterfowl predation probably had the most substantial effect on mussel densities (Petrie and Knapton 1999). A long-term study of changes in submerged vegetation in Long Point Bay showed changes in the vegetation community structure which also benefited waterfowl, probably as a result of increased light penetration associated with the filtering of suspended material by zebra mussels (Knapton and Petrie 1999).

It appears entirely likely that migrant and wintering waterfowl are responding to the feeding opportunities presented by mussels in Lake Ontario as well, with unknown long-term effects, and that dabbling ducks in the Bay of Quinte are responding to increasing aquatic vegetation, again related to the effects of abundant mussels.

Fish and Aquatic Communities

Fish and aquatic communities in at least some degraded nearshore areas have recovered significantly.

The nearshore waters of Lake Ontario include both shallow open waters exposed to wind and waves, and more sheltered embayments having relatively little exchange with the open Lake. While habitat conditions within this zone vary widely, in general the nearshore zone is more eutrophic than the open Lake, largely due to the formation of a "thermal bar" in spring and autumn which prevents complete mixing throughout the Lake during periods of maximum runoff (Barton 1986). While most Lake Ontario fish spend at least some part of their life cycle in the nearshore zone (Stewart *et al.* 1999), this zone has a distinctive fish and benthic invertebrate community.

Over the past 50 years, the nearshore zone has undergone major changes, although not to the extent of the offshore community, with the most extreme point of degradation in the 1950s and 1960s (Rang *et al.* 1992). In the early stages of degradation, excessive harvesting of some species and excessive eutrophication led to significant declines in pike, bass and walleye, and the growth of populations of pollution-tolerant species such as carp and white perch. In some areas, bioaccumulation of toxic substances in nearshore fish caused health effects such as tumours and led to restrictions on human consumption.

More recently, particularly over the past 20 years, a substantial improvement in nearshore aquatic habitat conditions and fish populations throughout the entire nearshore area has been observed, including:

- major reductions in sediment loads, total phosphorus and chlorophyll concentrations in nearshore waters, including in the Bay of Quinte;
- reductions in populations of algae and zooplankton associated with reduced nutrients and the filtering effects of zebra mussels;
- increased water clarity, leading to a proliferation of submerged aquatic plants and a possible move of light-sensitive predators like walleye to deeper waters;
- increasing abundance of predator species, including a resurgence of walleye populations; and
- a general decline in contaminant levels within nearshore fish species.

While the net effect of all these changes on fish habitats and populations is not certain, they will likely lead to an increase in species diversity (Stewart *et al.* 1999).

Because habitat conditions along the nearshore continue to evolve rapidly, particularly in response to zebra mussels, population fluctuations for individual fish species are to be expected. In the eastern sections of the Lake, for example, smallmouth bass populations have declined dramatically since 1991, yellow perch declined in the early 1990s but have since increased, and walleye abundance peaked in the early 1990s and has since declined (Hoyle 1999). For smallmouth bass, population declines may be linked to excessive predation pressure by double-

crested cormorants (Schneider *et al.* 1999), or to a series of cool summers in the early 1990s (Hoyle 1999). Generally, current fisheries objectives have not accounted for the new post zebra mussel productivity regime in the nearshore.

Other components of the nearshore food web have also responded to changing habitat conditions. Phytoplankton distribution is a valuable indication of habitat condition and ecosystem health in that their distribution is associated with nutrient content of the Lake (Busch *et al.* 1993). The phytoplankton of the Lake Ontario nearshore mostly represent assemblages associated with eutrophic environments and high chloride levels (Makarewicz 1987). Christie and Thomas (1981) mapped seven different phytoplankton zones within the Lake, with the nearshore area from Grimsby to Port Hope having the greatest diversity and abundance of species.

Reductions in phytoplankton densities consistent with reductions in total phosphorus loadings have been documented in areas such as the Bay of Quinte (Nicholls *et al.* 1986). A long-term comparison with data between 1945 and 1981 found only small differences in the densities of dominant phytoplankton species in the lower Bay of Quinte, but with early summer densities of blue-green algae more abundant in 1981 (Nicholls and Heintsch 1986). More recent reports suggest that after a relatively stable period of moderately high phytoplankton densities in the 1980s and early 1990s, significantly lower values began to be found in 1995, and there has been a shift to increasing diatoms and decreasing blue-green algae (Nicholls and Heintsch 1999). This appears to be related to the effects of rapidly-expanding zebra mussel populations.

Zooplankton are an important habitat component in Lake Ontario because they act as a primary food source for fish species such as alewife. The basic structure of the zooplankton community has not changed since the late 1960s, but during the 1980s abundance decreased in nearshore areas and there was a trend towards greater representation of smaller species (Johannsson *et al.* 1991). Nutrient availability and the degree of predation pressure appear to be significant controlling factors.

Benthic organisms, which reside in the bottom layer of the lake, are a major food source for predatory aquatic organisms, and an important pathway for energy flow in the ecosystem. The benthic fauna of Lake Ontario's Canadian nearshore is much less diverse than in Lake Huron, but more abundant, reflecting more eutrophic conditions (Barton 1986). The most abundant sites are located on silt and clay bottoms, especially near the mouth of the Humber River, and the least abundant on rock bottoms. Organic enrichment, depth, and susceptibility to upwelling are the primary factors influencing the composition of benthic invertebrate communities (Barton 1986).

Nearshore benthic populations and their habitats have been found to be heavily influenced by municipal and industrial outputs, with community abundance and diversity altered even to relatively deep depths near major river mouths on Lake Ontario (Nalepa 1991). While reports of acute toxicity are now virtually non-existent in Canada, the chronic effects of continuous long-term loading of low doses of persistent and bioaccumulative pollutants are little known and may pose a substantial threat to aquatic habitat and communities (Chambers *et al.* 1997). Benthic communities appear to be responding positively to improvements in water quality. For example, while there has been a general decline in the numbers and biomass of benthic invertebrates in the Bay of Quinte in response to lower phosphorus inputs, the mix of species there has shifted in favour of clean-water forms previously found only in adjacent Lake Ontario (Johnson and McNeil 1986).

4.4 Current Stressors and Impacts

Lake Level Regulation

Management of lake levels since 1960 has reduced the degree of year-to-year fluctuation and degraded natural shoreline processes.

The outflows of Lake Ontario have been regulated since 1960, following completion of the St. Lawrence Seaway and the Power Project. Plan 1958-D, the present regulation plan, was designed to meet the objectives specified in the International Joint Commission's (IJC) Order of Approval. One of the primary conditions in the IJC order was that Lake Ontario be regulated within a target range of 1.2 metres (Environment Canada and U.S. Army Corps of Engineers 1993). As shown in Figure 32, less variability in the range of lake levels has been experienced since the 1960s. Had there been no Lake Ontario regulation, the total range of fluctuation since 1960 would have been larger than that prior to 1960 (Environment Canada 2001).

Water level fluctuations are an integral component of the lake ecosystem, acting as a driving force in the creation, adaptation, and evolution of both life and landforms, and are primarily beneficial over time for the natural environment (Functional Group 2 1989). Alteration of lake levels and natural fluctuations has been identified as a major threat to the biodiversity elements of coastal marshes and dune systems (The Nature Conservancy 1994; Maynard and Wilcox 1996). Interruption of these dynamic natural features reduces the flushing of nutrients and organic matter, and causes a re-adjustment in the patterns of shoreline erosion and sediment patterns. Coastal wetlands are particularly affected.

Regulated water levels affect the natural range, frequency, timing and duration of water level-changes in coastal wetlands, and in turn reduce the extent and diversity of wetland plant communities and alter habitat quality for wetland fauna (Maynard and Wilcox 1996). Plant communities at elevations that are not flooded for many years become dominated by non-wetland shrubs, grasses, and old-field plants (Wilcox *et al.* 1993). Communities that stay almost constantly wet tend to be dominated by aquatic species. Plant and animal communities under these conditions become "fixed" and there is a loss of diversity (Sly 1991). Communities that experience periodic drying and flooding as a result of water-level changes have the greatest diversity of wetland vegetation, and develop into a dynamic "hemi-marsh" (interspersed open water and vegetation) state that is generally considered the most productive habitat within marshlands.

Reduced variability in water levels has resulted in extensive growth of dense cattail marsh in the Bay of Quinte, impacting its previous hemi-marsh condition (Crowder and Bristow 1986b). The lack of periodic summer low water levels has been cited as an important factor in the inability of Oshawa Second Marsh to regenerate healthy marsh conditions (Reid 1999).

In 1999, the IJC informed the two governments that it was becoming increasingly urgent to review the regulation of Lake Ontario outflows in view of dissatisfaction, on the part of some interests, with the management of that system and in light of environmental concerns and climate change issues (International Joint Commission 1999). Subsequently, a study to review

the water level regulation plan for Lake Ontario and the St. Lawrence River was initiated in the fall of 2000. The purpose of the review is to ensure that the needs of all users in the Lake Ontario-St. Lawrence River system are taken into consideration. The study will include a full evaluation of the impacts of water level fluctuations on coastal wetlands. This presents an important opportunity to address a significant stressor on these habitats.

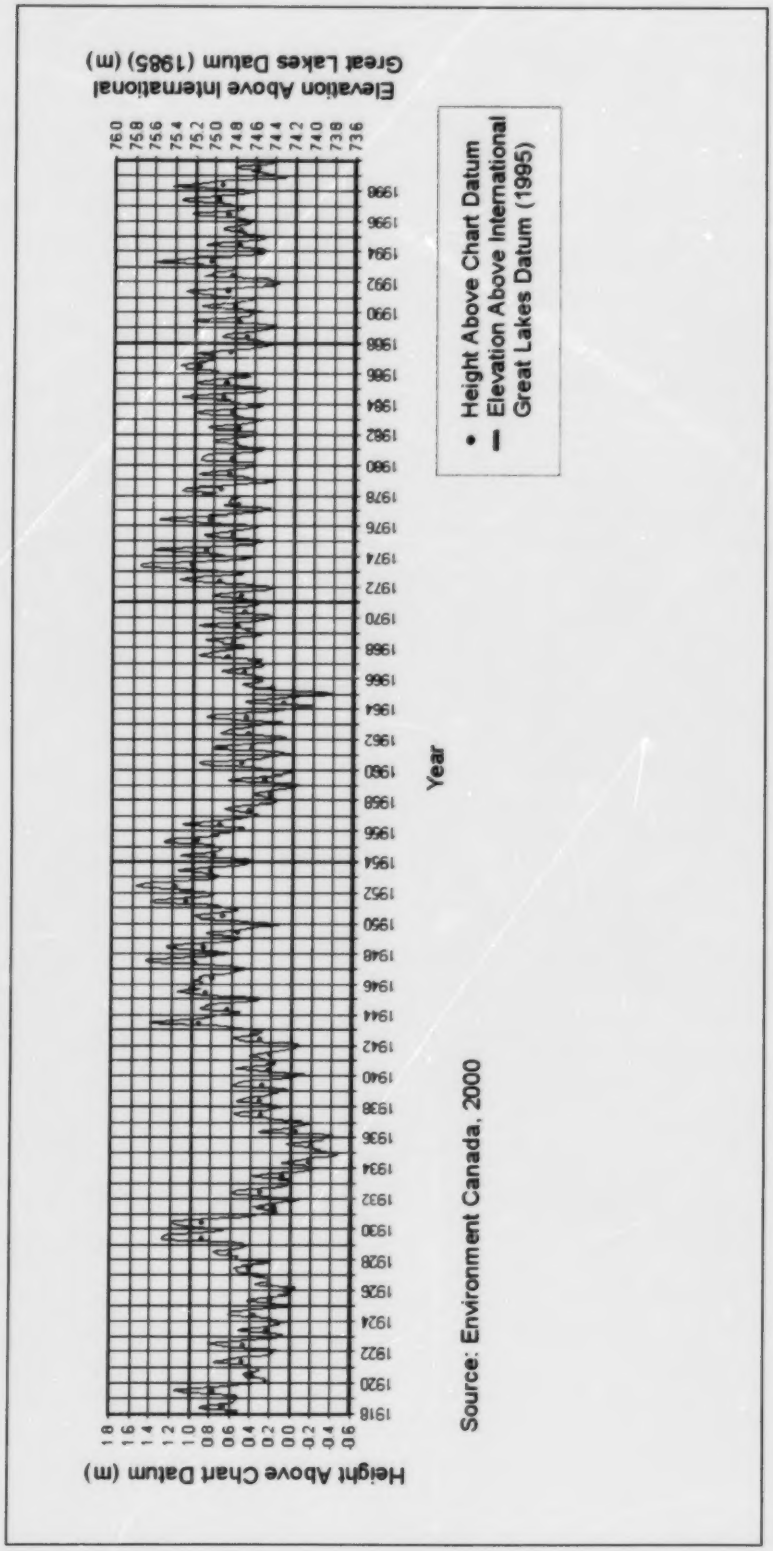


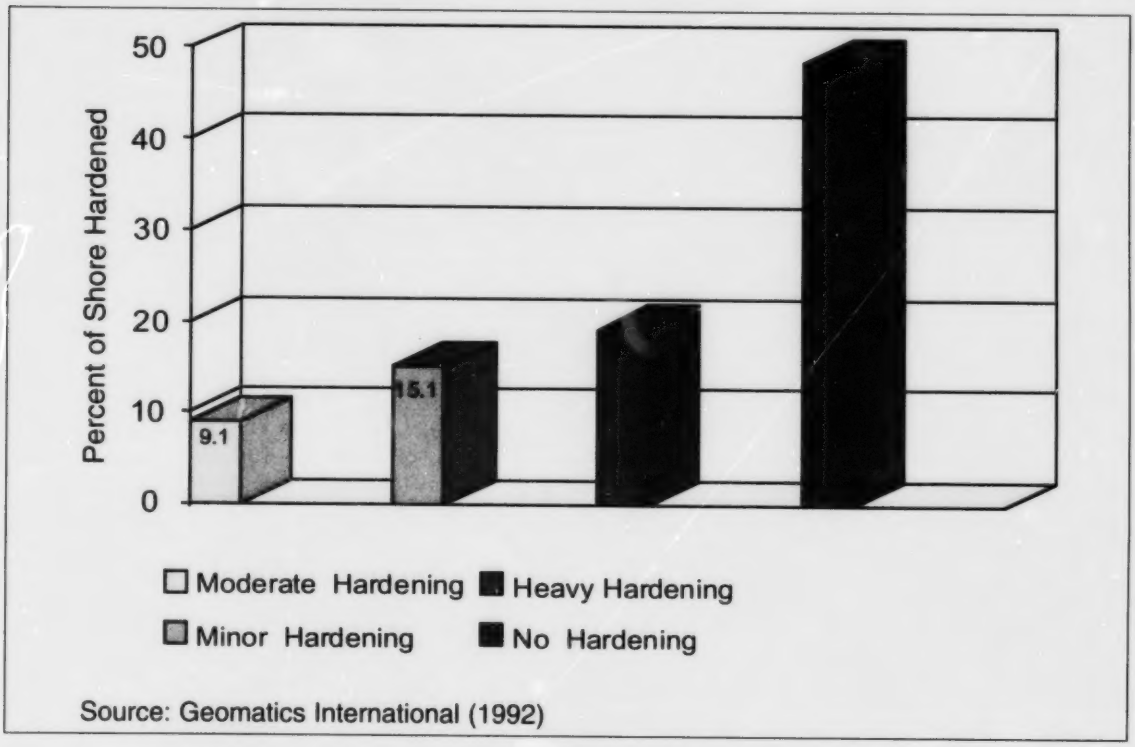
Figure 32. Lake Ontario water levels: 1918 to 1999

Shoreline Hardening

Shoreline hardening and artificial structures have impaired natural erosion and sediment transport processes in the western sections of the Lake.

In response to natural flooding or erosion events or to extend industrial or other land uses, many sections of the Lake Ontario shoreline have been modified. These modifications take a variety of forms, from sheetpile or concrete seawalls, to large stone or boulder riprap, to groynes extending into the lake at right angles to the shore. Their current extent, as of 1992, is summarized in Figure 33.

Figure 33. Shoreline hardening on Lake Ontario



Source: Geomatics International (1992)

The majority of shoreline hardening has taken place in the western sections of Lake Ontario, since the occurrence of bedrock shores and the less intensive land use east of the Oshawa area lessen the demand for stabilizing shoreline. Within the western sections, moderately and heavily protected shorelines total approximately 35 to 38 percent of the coast (Geomatics International 1992).

This hardening of the shoreline has resulted in a change of the ecological processes associated with shorelines, and disrupted the lake's natural water and sediment circulation processes. Beach areas that were regularly cleansed by the dynamics of wind and waves are no longer cleansed. Strips of aquatic vegetation that required regular removal of decomposing organic material have been choked out. Deposits of sediment that would normally have passed through the nearshore area are now deposited against piers and weirs. Sediment and pollutants from the

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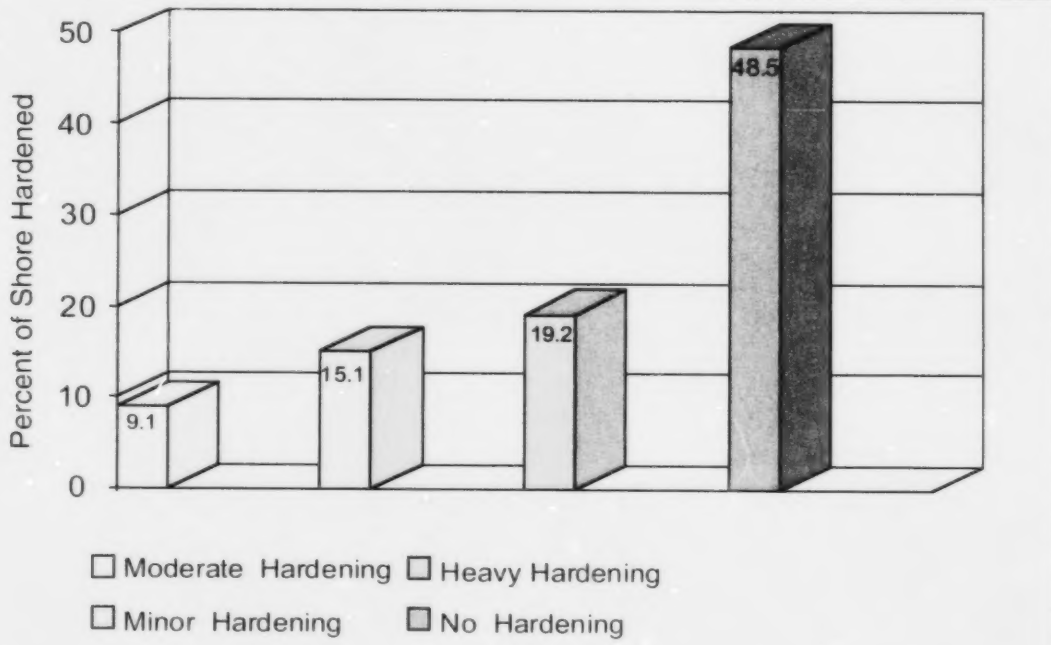


Source: Geomatics International (1992)

The majority of shoreline hardening has taken place in the western sections of Lake Ontario, since the occurrence of bedrock shores and the less intensive land use east of the Oshawa area lessen the demand for stabilizing shoreline. Within the western sections, moderately and heavily protected shorelines total approximately 35 to 38 percent of the coast (Geomatics International 1992).

This hardening of the shoreline has resulted in a change of the ecological processes associated with shorelines, and disrupted the lake's natural water and sediment circulation processes. Beach areas that were regularly cleansed by the dynamics of wind and waves are no longer cleansed. Strips of aquatic vegetation that required regular removal of decomposing organic material have been choked out. Deposits of sediment that would normally have passed through the nearshore area are now deposited against piers and weirs. Sediment and pollutants from the

land are deposited in the nearshore littoral zone rather than moving into openwater areas to become diluted and flushed (Croskery 1995).

The interruption of the transport of sediments along the shore can cause sand starvation to beach, dune, and coastal marsh communities and the species they support (The Nature Conservancy 1994). The Burlington Beach bar in the western basin is a good example of a baymouth deposit that has been significantly altered by a combination of sand and gravel removal, cottage construction on dune areas, and elimination of most or all of its sediment supply. The historical source of sediment for this beach was the erosion of the south shore between Hamilton and Niagara. This sediment supply has been cut off by channel jetties, and there is no net littoral drift to this feature (Waterfront Regeneration Trust 1996).

Barrier beach wetlands may lose the protection of a barrier beach and be impacted by waves. When major storms remove areas of shoreline marsh, the lack of sediment supply to re-accumulate may prevent wetland conditions from being re-established. When dikes or breakwalls are constructed along the gently sloping shore of a wetland, these structures eliminate the ability of the marsh to shift shoreward during high water levels, and may result in the scouring of shallow bottom areas to create a more abrupt boundary between upland and deep water (Maynard and Wilcox 1996).

Hard shoreline structures also shift wave energy further downshore and may locally accelerate erosion of beaches and coastal wetlands elsewhere. This process tends to reinforce the hardening process, as shoreline landowners respond to problems created by the actions of their neighbours.

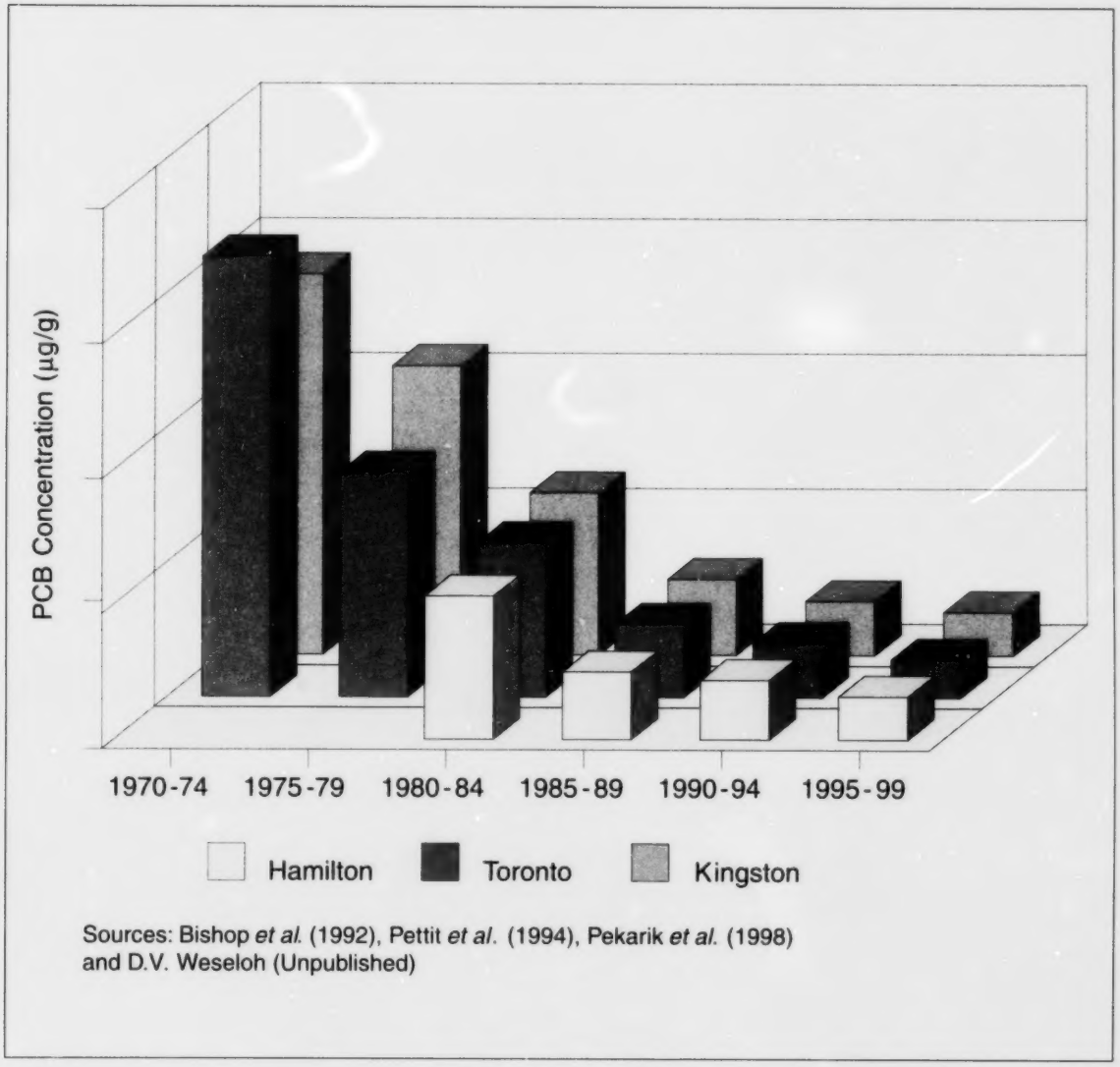
In many of the urban areas along the Lake Ontario coast, lakefill structures, such as spits, breakwalls, groynes, etc., have been extended into the Lake. These have created highly-valued recreation areas, as well as pockets of warm-water fisheries habitat sheltered from cold upwellings from the open Lake. In some cases, they have also interfered with the mixing and dispersal of polluted water, creating contaminated embayments, blocked the movement of sand towards local beaches, and likely accelerated the erosion of nearby bluffs (Shoreline Regeneration Work Group 1991).

Nutrients and Contaminants

Nearshore loadings of nutrients and toxic contaminants have declined significantly over the past four decades, but remain above target levels in some areas.

Specific issues related to toxic contaminants within the Lake Ontario ecosystem were previously addressed through the Lake Ontario Toxics Management Plan (Lake Ontario Toxics Management Plan 1989) and are now a priority under the binational Lake Ontario LaMP. In general, the levels of toxic contaminants in nearshore waters, sediments, fish and wildlife have declined significantly, in many cases to below target levels (Environment Canada *et al.* 1998a). However, a few substances, notably polychlorinated biphenyls (PCBs) and other critical pollutants such as mirex, DDT (dichlorodiphenyl trichloroethane), dioxin, mercury and dieldrin, remain at elevated levels. Site-specific areas of contamination are being addressed through agency programs, RAPs and LaMP source reduction programs. Figure 34 provides an example of the decline in contaminants, showing PCB levels in herring gull eggs in three parts of the Lake.

Figure 34. PCB concentrations* in herring gull eggs from Lake Ontario colonies 1970 to 1999



Sources: Bishop *et al.* (1992), Pettit *et al.* (1994), Pekarik *et al.* (1998) and D.V. Weseloh (Unpublished)

* PCB concentrations were analyzed as Aroclor 1254:1260 (1:1)

Contaminant levels in snapping turtles have been measured at four wetlands along the Lake Ontario shore, since this long-lived, sedentary species tends to accumulate persistent toxins. In the mid-1980s, high concentrations of dioxins and a large number of furans were documented in snapping turtle eggs from Cootes Paradise and Lynde Creek, although concentrations of dioxins and furans declined markedly at the former site from 1984 to 1989. Contrastingly, levels of PCBs and DDE (dichlorodiphenyldichloroethylene) in eggs from Cootes Paradise and/or Lynde Creek increased significantly from 1984 to 1990/91 (Bishop *et al.* 1996). These

contaminant levels appear to be having an effect on the health of snapping turtles at these sites, since a study by Bishop *et al.* (1991) demonstrated that eggs with the highest contaminant levels showed the poorest developmental success. Data from more recent years are unfortunately not yet available.

In open coast areas, reductions in phosphorus levels have approximated the levels for the open Lake, which have been reduced by more than two-thirds (Sly 1991; Ontario Ministry of the Environment 1999c). Special attention has also been directed towards sheltered nearshore embayments such as Hamilton Harbour and the Bay of Quinte, and a combination of upgraded sewage treatment and watershed stewardship measures have significantly reduced nutrient inputs there as well. For example, in the Bay of Quinte total phosphorus concentrations have dropped from over 80 milligrams per litre in the early 1970s to levels near or below the target of 30 milligrams per litre in recent years (Nicholls and Heintsch 1999). Chlorophyll levels have shown a corresponding decline.

Exotic Species

The continued introduction and population growth of non-native species is affecting the stability of nearshore natural ecosystems, with uncertain long-term results.

The introduction of non-native, or exotic, species to Lake Ontario has had a marked impact on the fish community and food-web structure of the lake, and in some cases, is modifying the habitat itself. Many introduced species become firmly established only after the destabilization of indigenous communities through such stresses as watershed deforestation or overfishing (Sly 1991).

Since the 1800s, at least 139 non-indigenous aquatic organisms have become established in the Great Lakes (Great Lakes Commission 1997). These include 59 species of plants, 25 fish, 24 algae, 14 molluscs, and seven oligochaetes. About 55 percent of these species are native to Eurasia; 13 percent are from the Atlantic coast, with the major entry mechanisms being unintentional releases and ship ballast water. More than one-third of these non-native organisms have been introduced during the past 30 years, a surge coinciding with the opening of the St. Lawrence Seaway (Great Lakes Commission 1997).

About 10 percent of introduced species have had significant ecological and economic impacts. A few species have become so abundant as to affect the stability of natural ecosystems. This may take place through competition of non-native species (e.g., carp, alewife, rainbow smelt) with native species, with the result that non-native species become dominant within nearshore fish communities. Some species modify habitat conditions for fish and wildlife. For example, purple loosestrife replaces native cattails and other marsh species, resulting in poorer habitat conditions for a wide range of marsh wildlife. Eurasian watermilfoil can crowd out native aquatic plants in shallow areas. A similar threat likely to affect Lake Ontario in the future is an exotic water weed called hydrilla, which is now the most abundant aquatic weed in Florida, and is invading northwards (Nalbone 2000).

Without question, however, the non-native organisms with the greatest recent impact on the nearshore environment of Lake Ontario have been zebra and quagga mussels. The recent invasion of zebra and quagga mussels into Lake Ontario has caused rapid changes in how

nutrients are cycled through food webs. The mussels colonized western Lake Ontario by 1991 to 1992, the eastern Outlet basin by 1993, and the Bay of Quinte by 1994 (Bailey *et al.* 1999). The populations of these mussels are such that their turnover time for the entire Lake Ontario water volume is about one year, and in the Bay of Quinte, about 0.05, 0.2 and 10 days for the lower, middle, and upper areas of the Bay, respectively (Bailey *et al.* 1999). Their abundance has had ramifications throughout the nearshore ecosystem, including:

- exaggerating the effects of nutrient abatement by filtering and clarifying the water column;
- diverting energy flow to the benthic community, away from the pelagic species such as alewife and smelt;
- increasingly dominating nearshore benthic communities, and significantly changing the composition and abundance of phytoplankton and zooplankton communities;
- contributing to or causing shifts in nearshore and offshore fish communities to favour those more adapted to less productive, clearer waters, and decreasing food sources for species such as whitefish and slimy sculpin;
- increasing bioaccumulation of persistent toxins within the nearshore environment food web;
- changing the distribution and timing of use of the nearshore area by migrant waterfowl; and
- leading to declines in native clam populations (Wormington and Leach 1992; Croskery 1995; Environment Canada *et al.* 1998a; Hoyle 1999; Stewart *et al.* 1999).

There is evidence that zebra and quagga mussel populations are declining in some areas, probably as a result of waterfowl predation (Petrie and Knapton 1999). In their review of impacts in Lake Ontario, Bailey *et al.*(1999) conclude that "the mussels may not have a huge impact on the Lake Ontario food web when considered at a whole-lake scale, but their potentially striking impact at the smaller spatial scale of embayments like the Bay of Quinte indicate that they may be locally important. When these effects are aggregated across several sub-systems, Dreissenidae mussels may have unpredictable, larger scale effects in the Lake Ontario ecosystem as a whole."

Climate Change

Climate change could cause nearshore habitat changes at a rate faster than the ecosystem's capacity to respond.

As noted in Section 3.4, climate change is expected to exert a considerable impact on aquatic ecosystems in coming years. Among the most profound effects are likely to be a lowering of lake levels, and an increase in water temperatures (Smith *et al.* 1998). While water level changes in Lake Ontario are likely to be lessened, at least in the short term, by the existing lake

level management regime, the need to maintain flows downstream to the City of Montreal and the St. Lawrence River may well affect lake levels in the face of decreasing inflow. Among the potential effects on nearshore habitat are:

- a potential lakeward shift in both aquatic and terrestrial habitat types in response to lower mean water levels;
- changes in shoreline erosion, sediment transport, and deposition patterns, resulting both from shifts in the shoreline edge and from a greater frequency of storm events;
- changes in fish community reproduction and survival, with greater advantage to species such as white perch that are vulnerable to prolonged cold winters;
- an increased rate of vulnerability to invasion by exotic species;
- reduced winter ice cover and duration, potentially leading to changes in water clarity and productivity, and to shifting use by wintering waterfowl;
- reduced tributary flows, with probable impacts on the reproduction of anadramous fish species, and potential changes to the entry pathways of nutrients and other pollutants; and
- major potential impacts on coastal wetlands dynamics and functions, particularly in wetlands impeded from adapting to new water level conditions by man-made structures or geomorphic conditions (Sly 1991; Mortsch 1998; Smith *et al.* 1998).

4.5 Summary of Impairment, Information Gaps, and Emerging Issues

- Nearshore habitats on Lake Ontario are poorer in quality and diversity now than they were at the time of European settlement, in large part because of changes associated with historic land use and shoreline development.
- Nearshore terrestrial habitats, including forest cover, interior forest, urban forest and lower valley corridors, are in limited supply and are declining further.
- Most occurrences of special lakeshore ecological communities lack long-term protection from alteration.
- Nearshore wetlands are significantly depleted from their former extent, and continue to be threatened by habitat alteration, water level controls, and sedimentation.
- Populations of most colonial nesting waterbirds have increased as nearshore contaminant loadings have dropped, but common terns continue to decline and ospreys and eagles have not yet returned.
- Seasonal waterfowl use along the Lake Ontario shore has shifted, likely in response to zebra and quagga mussel populations.
- Aquatic communities in at least some degraded nearshore areas have recovered significantly, particularly in response to reduced phosphorus levels. However, habitat loss and alteration, rather than nutrients and contaminants, have had a more significant effect on the health of fish populations.
- Management of lake levels and shoreline hardening have degraded natural shoreline processes and negatively affected habitats.
- The continued introduction and population growth of non-native species is affecting the stability of nearshore ecosystems, with uncertain long-term results.
- Climate change could create nearshore habitat changes at a rate faster than the ecosystem's capacity to respond.
- The development of a digitally-based data set for nearshore physical data such as bottom sediments and depth contours would add greatly to scientific predictive capability for such stressors as climate change.
- Further research is needed on the effects on coastal wetlands and potential management responses for lake level controls and climate change; coordinated multi-site wetland monitoring programs should be developed to allow data comparison and identification of broad-scale trends.
- Future fisheries management of the nearshore zone will need to incorporate the ability to rapidly adapt to unexpected changes, such as those brought about by the zebra and quagga mussel invasions.

5.0 Offshore Waters of Lake Ontario

5.1 Habitat Characteristics and Historical Changes

Lake Ontario has a relatively deep, smooth-sided basin, with the steepest slopes into deep waters along its south coast (Figure 35). This lack of topographic diversity on the lake bottom means that other habitat features, such as water temperature and oxygen levels, play a major role in defining habitat conditions.

The offshore characteristics of Lake Ontario are closely linked to four main sedimentation basins (Table 15), which are separated by sills of glacial material and limestone bedrock, as shown in Figure 36 (Thomas 1983). These basins act as repositories for fine-particle sediments, with the Rochester basin experiencing a particularly high rate of sedimentation (Martini and Bowlby 1991). Relatively little of this sediment is derived from shore erosion; most of it comes from river inputs, with 50 percent of the total input from the Niagara River. As a result, these sediments are contaminated by a variety of toxins from the Niagara River and Lake Erie and they tend to remain within the bottom sediments of Lake Ontario (Oliver *et al.* 1989).

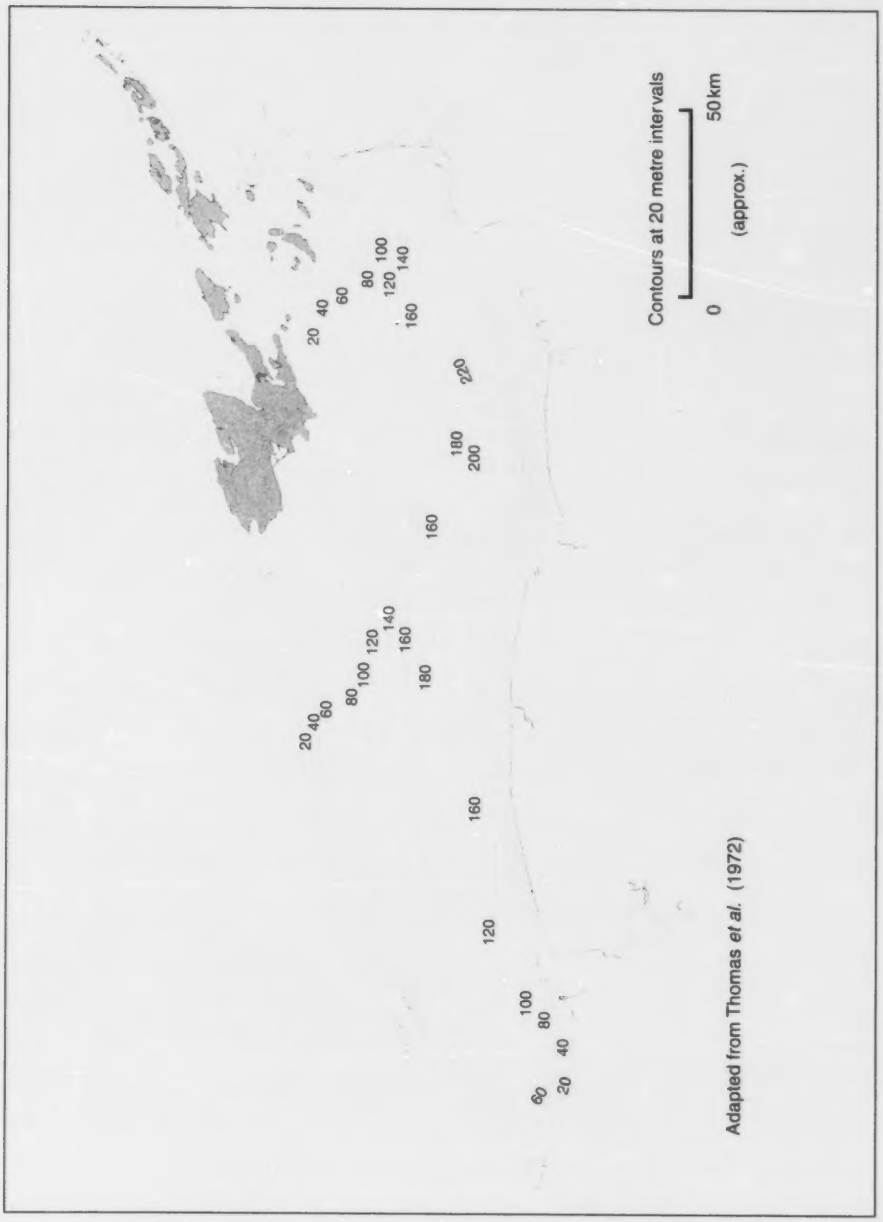
Table 15: Summary of basin characteristics of Lake Ontario

	Niagara Basin	**Mississauga Basin**	**Rochester Basin**	**Outlet Basin**
Max. depth	120 m	180 m	220 m	40 m
Sedimentation rate (million metric tonnes per year)	0.75	0.70	2.59	0.72
Phytoplankton communities	Greatest diversity and abundance	Low abundance; west-east shift in species	Low abundance; west-east shift in species	High abundance; of eutrophic species
Benthic communities	Mix of species; some tolerant of enriched conditions	Dominated by oligotrophic species	Dominated by oligotrophic species	Mix of species, including some eutrophic species

Based on: Nalepa and Thomas (1976); Christie and Thomas (1981); Martini and Bowlby (1991)

Water temperature is an important habitat characteristic of offshore waters. Large variations in temperature result from the formation of bands of warm nearshore water known as thermal bars during the spring, from the establishment of a thermocline during summer months, and from wind-driven mixing and movement of water. Mixing of offshore waters, particularly during spring and fall turnover events, also means water quality is more consistent over large areas, as opposed to the variability encountered in nearshore zones.

Figure 35. Bathymetry of Lake Ontario



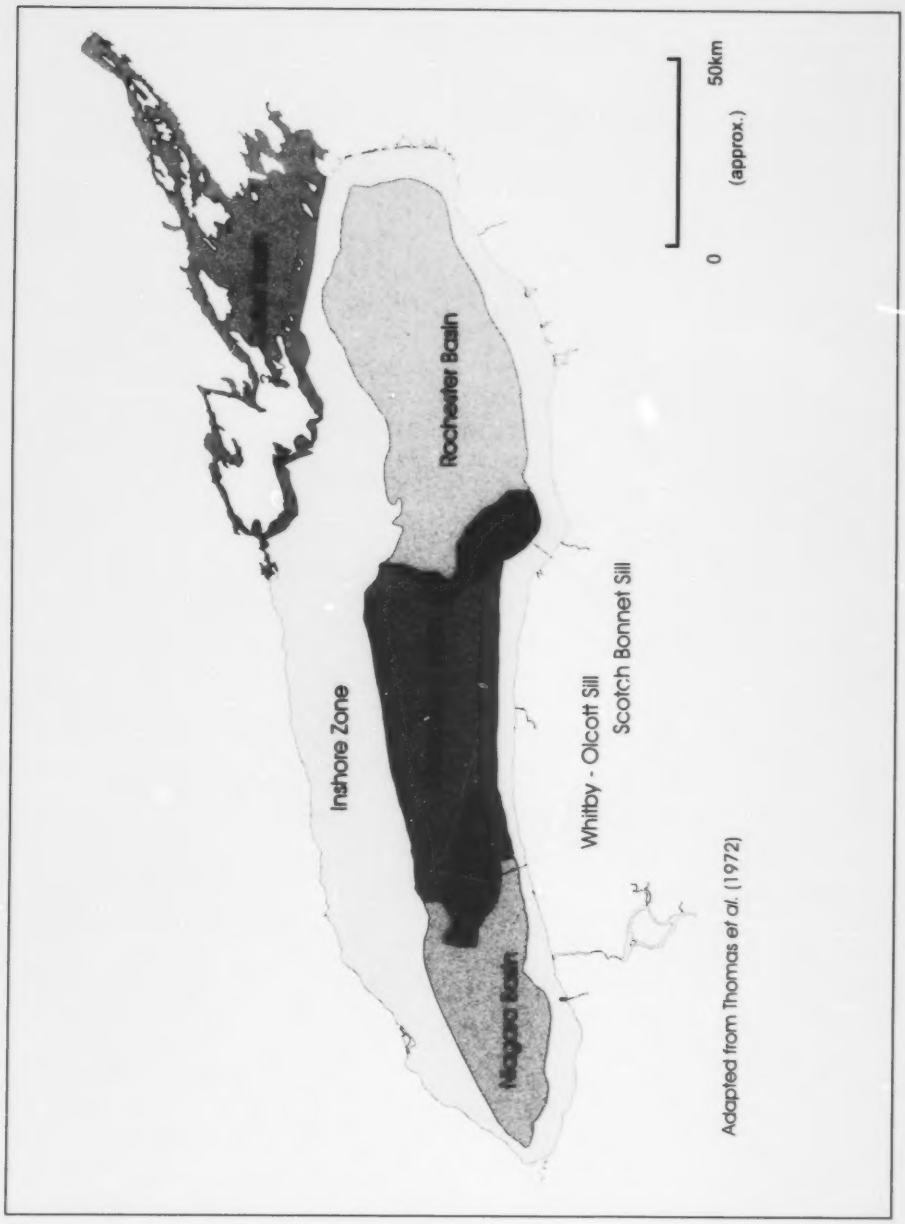


Figure 36. Sedimentation basins of Lake Ontario

Food webs in the offshore zone can be subdivided into a pelagic or open-water web, and a benthic or bottom-related web. The pelagic food web consists of small prey fish, such as alewife and rainbow smelt, that feed on zooplankton including cladocerans, copepods, opossum shrimp, spiny water flea, and others. In turn, the prey fish are eaten by large predatory fish including chinook and coho salmon, and rainbow, brown and lake trout. The offshore benthic food web is based on several species of deepwater zooplankton and other invertebrates, especially a burrowing amphipod called Diporeia (formerly known as Pontoporeia). The benthic fish community is dominated by lake trout, slimy sculpins, and low numbers of burbot, with lake whitefish abundant in northeast waters (Stewart *et al.* 1999).

The dynamics of these offshore communities are complex, with major influences on the fish and aquatic communities including nutrient levels, population levels of introduced plankton-eaters such as alewife and rainbow smelt, and stocking rates of introduced predators such as Pacific coast salmonids (Stewart *et al.* 1999). Historically, commercial overfishing of desired species was probably also a major destabilizing influence (Busch *et al.* 1993).

At the time of European settlement, Lake Ontario was an oligotrophic, or nutrient-poor, lake, with lake trout, Atlantic salmon, and burbot as top predators. Lake herring, lake whitefish, and deepwater sculpin were the primary forage fish. By the 1960s, all of these native species were either extirpated or severely depressed in numbers; the victims of overfishing, habitat destruction, the introduction of exotic species, and nutrient enrichment. In their place, exotic forage fish such as alewife, rainbow smelt, and white perch increased dramatically. Large piscivores had been virtually eliminated (Stewart *et al.* 1999)

Since the 1960s, fish communities and other biota have undergone dramatic improvements as levels of nutrients and toxic contaminants in the lake ecosystem have been brought under control. Government stocking programs, largely of Pacific salmonids, along with suppression of sea lampreys, have developed a new class of aquatic predators (Environment Canada *et al.* 1998a). While fish communities are largely based on non-native species, for many people the ability to catch large salmon in Lake Ontario has symbolized the recovery of this degraded ecosystem.

5.2 Defined Habitat Goals for Offshore Lake Ontario

The Lake Ontario Committee (LOC) of the Great Lakes Fishery Commission has recently established objectives for Lake Ontario offshore pelagic and benthic fish communities. These are as follows:

The offshore pelagic fish community will be characterized by:

- a diversity of salmon and trout;
- chinook salmon as the top predator;
- abundant populations of rainbow trout (steelhead);
- fishable populations of coho salmon and brown trout;

- populations of stocked Atlantic salmon at levels consistent with investigating the feasibility of restoring self-sustaining populations;
- amounts of naturally produced (wild) salmon and trout, especially rainbow trout, that are consistent with fishery and watershed plans; and
- a diverse prey-fish community with the alewife as an important species.

The offshore benthic fish community will be composed of self-sustaining native fishes characterized by:

- lake trout as the top predator;
- a population expansion of lake whitefish from northeastern waters to other areas of the Lake; and
- rehabilitated native prey fish populations (Stewart *et al.* 1999).

These objectives nest within broader policy objectives set through *A Joint Strategic Plan for the Management of Great Lakes Fisheries* (Great Lakes Fishery Commission 1997) and the *Policy for the Conservation and Rehabilitation of Aquatic Habitat in the Great Lakes* (Great Lakes Fishery Commission 1999), which urges that:

- all feasible and prudent measures be taken to prevent further losses of aquatic habitat, and to provide for rehabilitation of degraded habitat throughout the Great Lakes ecosystem;
- fishery agencies cooperatively exercise their full authority and influence in every available arena to meet the biological, chemical, and physical needs for sustainable fish communities, and
- fishery and environmental management agencies work together to (1) improve water quality; (2) provide for rehabilitation of degraded habitat throughout the Great Lakes ecosystem; (3) achieve net gains in the quantity and quality of aquatic habitats; (4) advocate reductions of toxic substances to levels that do not impair the health of aquatic organisms nor the wholesomeness of fish for consumption by humans and wildlife; and (5) prevent the unauthorized introduction of non-native organisms.

Criteria for acceptable levels of various toxic materials have been established as water quality and/or fish tissue standards, objectives, criteria, or guidelines, in conjunction with the implementation of the Great Lakes Water Quality Agreement. These criteria and current status and progress will be discussed in detail in future Lake Ontario Lakewide Management Plan (LaMP) documents.

One important criterion for the recovery of Lake Ontario habitats is the target of 10 micrograms per litre for spring concentrations of total phosphorus in the open lake which was established through the 1972 Great Lakes Water Quality Agreement.

5.3 Current Status and Recent Trends

Nutrient Levels

Phosphorus and other nutrient levels have declined markedly over the past 30 years, and related effects such as improved water clarity are currently being exaggerated by zebra and quagga mussels.

In 1973, when total phosphorus levels reached their maximum, degradation was apparent across Lake Ontario with large algal blooms, die-offs of alewives, and only remnants of native fish communities remaining. Since 1983, spring total phosphorus levels have remained close to the Lake Ontario water quality objective of 10 micrograms per litre, with one anomalous peak in 1991 associated with an unusually high load from the Niagara River. (Sly 1991; Johannsson *et al.* 1998). Particulate organic carbon and nitrogen concentrations during the stratified summer period have also declined in step with total phosphorus levels in Lake Ontario. Phosphorus levels have continued to decline in the Outlet basin during the 1990s, but not in the mid-lake (Johannsson *et al.* 1998).

The invasion of zebra and quagga mussels into western Lake Ontario in 1991 and 1992 and the Outlet basin by 1993 tended to exaggerate the effects of nutrient abatement by the rapid filtering and clarifying of the water column (Bailey *et al.* 1999). Because the mussels are established most prolifically along the southern shore of the Lake and in the Outlet basin, the effects have been observed most markedly there. For example, while water clarity has increased significantly in the mid-lake since the late 1980s, this change was more pronounced in the Outlet basin. Soluble reactive silica concentrations also increased in the Outlet basin in the 1987 to 1995 period, likely because of a combination of three factors: local cropping of diatoms (which normally use up available silica) by mussels; reduced diatom growth rates because of falling phosphorus concentrations; and higher silica concentrations in waters arriving from Lake Erie and the Lake Ontario south shore where mussel impacts are largest (Johannsson *et al.* 1998).

In short, the continuing reductions in total phosphorus levels in the Outlet basin may be the result of filtering by mussels, but similar impacts had not yet been seen in the mid-lake area by the mid-1990s.

Fish and Aquatic Communities

Offshore pelagic fish communities have become very unstable in response to changing habitat conditions and predator-prey relationships, especially related to alewife abundance.

The offshore prey-fish community of Lake Ontario is less diverse now than it was historically, with only a small population of the lake herring remaining from a historic community of four species of ciscoes. One of the three species of sculpins, the deepwater sculpin, was thought to have been eliminated from the Lake, but three specimens were found in 1996 (Stewart *et al.* 1999). Small numbers of this species, which is listed as a threatened species by Committee on the Status of Endangered Wildlife in Canada (COSEWIC), were also captured on the American side of Lake Ontario during 1998 and 1999.

An introduced species, the alewife, exerts the dominant biotic influence on offshore fish communities, with the rainbow smelt as another important prey species. Both alewife and smelt populations have declined significantly over the past two decades, in part because of lower plankton levels related to decreasing nutrient levels and the effects of zebra and quagga mussels, and in part because of predatory pressures from stocked salmonids (Schaner and Lantry 1999). As alewife abundance decreased:

- lake trout began to successfully reproduce;
- threespine stickleback abundance increased;
- lake whitefish populations recovered; and
- populations of other native fish species (e.g., yellow perch, emerald shiner, and lake herring) improved (Stewart *et al.* 1999).

A diet high in alewives has been shown to cause early mortality syndrome in the offspring of lake trout, presumably because of thiamine deficiencies, and is likely a major impediment to establishing a self-reproducing lake trout population, and possibly Atlantic salmon as well (Stewart *et al.* 1999). In light of concerns about declining alewife populations, since this species is the preferred prey for chinook salmon, stocking rates of salmon and trout to Lake Ontario were reduced by almost 50 percent in 1994, but moderately increased again in 1997 in response to public consultation.

The future of the Lake's pelagic fish community at this point is very uncertain. Achieving the fish community objective of having chinook salmon as the top predator is highly dependent on rebounding alewife abundance. If alewife populations decline markedly, fish with more general diet preferences such as rainbow and lake trout will likely fare better, with improved reproduction of native species. The quality of spawning and nursery habitat in tributaries and improvements in fish passage are critical factors for anadramous species such as rainbow trout. Re-establishment of a diverse native prey-fish community is highly uncertain (Stewart *et al.* 1999).

Offshore benthic fish communities have shown recent improvements, but the impact of zebra and quagga mussels makes further improvement uncertain.

Improvements to water quality, large-scale salmonid stocking programs, sea lamprey control, and commercial harvest control have led to the recovery of some species associated with the lake bottom, especially in the eastern sections of the Lake. Lake whitefish recovered during the 1980s, and a large lake trout population, built up by large-scale stocking, produced notable numbers of wild fish starting in 1993. Lake herring showed an increase in recruitment in 1990 and an increasing adult population in at least some areas. Significant numbers of young lake sturgeon have been reported by commercial fishermen in eastern Lake Ontario since 1996 (Hoyle 1999).

However, the combined effects of lowered phosphorus levels offshore and the impacts of zebra and quagga mussels on invertebrate populations make sustainability of this recovery uncertain. The loss of the deepwater amphipod Diporeia from large areas of Lake Ontario and

observations of emaciated whitefish are good examples of the uncertainty associated with exotic mussels (Stewart *et al.* 1999). Having peaked in 1993, lake whitefish abundance and body condition now appears to be in decline in eastern Lake Ontario (Hoyle *et al.* 1999). A diet study conducted in 1998 in the Outlet basin indicates that zebra and quagga mussels now dominate the diet of whitefish in that area (Hoyle 1999).

Phytoplankton and zooplankton community structure and abundance are shifting in response to phosphorus reductions and mussel invasion.

Phytoplankton, the microscopic aquatic plants such as algae and diatoms that form the basis of the offshore food web, respond to changes in nutrient levels and to predation levels by alewives and rainbow smelt. Several long-term studies have documented changes in phytoplankton. In the mid-lake, no trend in total algal biomass or chlorophyll levels was discerned between 1981 and 1985, although year-to-year variability was high. However, the composition of phytoplankton communities has changed, with edible types of algae decreasing and less edible forms increasing. In the Outlet basin, a significant decline in chlorophyll levels and total algal biomass took place (Johannsson *et al.* 1998).

Over a longer time frame, data comparisons between 1972 and the 1987 to 1992 period showed that seasonal phytoplankton photosynthesis — a measure of the lake's primary productivity — may have declined by about 30 percent (Millard *et al.* 1996). While this may be a welcome development in reducing the shoreline algal mats that once fouled Lake Ontario, it also suggests a lower productivity for future fish populations, which may present a management challenge.

Lake Ontario zooplankton — tiny aquatic animals that are an important food for plankton-eating fish — are showing a similar pattern of changes. The basic nature of the zooplankton community does not appear to have changed since the late 1960s, being dominated by small "microzooplankton" species. This predominance of small species is characteristic of systems dominated by alewives feeding selectively on larger individuals (Johannsson *et al.* 1991). A recent study showed that microzooplankton are still dominant and their consumption of primary production in Lake Ontario is low, suggesting that the introduction of alewives has created a longer, perhaps inefficient food chain. This structure may create a higher factor of biomagnification of organic chemicals for top-level predators along with lower rates of energy transfer within the food web and lower fish production (Lampman and Makarewicz 1999).

Zooplankton production has responded to changes in total phosphorus and phytoplankton (such as the shift to less edible forms), as well as to grazing by alewives, with reductions of approximately 50 percent in their summer biomass (Environment Canada *et al.* 1998a; Johannsson *et al.* 1998). This reduction in abundance was found both in the open lake and in the Outlet basin.

To this point, zebra and quagga mussels appear to have affected significant declines in the standing crop of some phytoplankton species and the productivity of zooplankton in the Outlet basin area of the Lake, but impacts associated with their continuing spread into deeper offshore waters in the main lake basin are yet to be felt (Johannsson *et al.* 1998).

The abundance of benthic organisms in offshore areas has declined significantly since the 1960s, and changes in species composition have occurred recently.

Benthic organisms live in direct contact with the lake bottom sediments, and are an important food source for fish and other aquatic life. In general, the benthos of Lake Ontario has been similar to the other Great Lakes, with offshore areas dominated by small crustaceans and mysids (opposum shrimp). Until the 1960s, the crustacean *Diporeia* accounted for 80 to 90 percent of benthic secondary production in the eastern end of the Lake and nearly 70 percent in the main basin (Sly 1991). Since benthic communities were first documented in the 1960s, several changes have been observed.

First, Nalepa (1991) noted that benthic biomass was less than might be expected given the amount of organic matter settling into the bottom, and that benthic standing stocks in the offshore region had apparently declined almost threefold since the 1960s, a decline that might be related to the accumulation of contaminants. A second study, comparing historical records from the mid-1960s to the early 1990s provided evidence of two major shifts in the abundance of benthic animals (Barton and Anholt 1997). Numbers of oligochaetes (worms) decreased by about 40 percent during 1965 and remained at the lower levels through 1990. The abundance of *Diporeia* changed little from 1964 through 1977, but increased sharply between 1977 and 1981. These shifts were thought likely to be the result of changes in fish and zooplankton communities and inputs of toxic contaminants.

In the past several years, however, since the introduction of zebra and quagga mussels, there has been a dramatic decline in *Diporeia* abundance in eastern Lake Ontario (Hoyle 1999) and a loss of the species from large areas of the Lake (Stewart *et al.* 1999). The decline of this formerly abundant species, which has been considered an indicator of good environmental quality in the Lake, is a signal of significant instability in benthic communities.

5.4 Current Stressors and Impacts

Nutrient and Toxic Contaminant Inputs

Nutrient levels are no longer problematic, but the role of toxic contaminants in the offshore benthic environment needs further assessment.

In response to phosphorus control programs, open lake concentrations have declined to well below the guideline established in the early 1970s. Since the early 1980s, water clarity has increased by 20 percent, photosynthesis has declined approximately 18 percent, and late summer zooplankton production has declined by 50 percent * all positive changes reflecting an overall shift of the lake back towards its original condition of low nutrient levels. It appears that eutrophication is no longer a problem in offshore waters (Environment Canada *et al.* 1998a).

The significance of toxic contaminant inputs to the Lake, or of persistent contaminants resident in the bottom sediments, is less clear. As noted in the previous section, several authors (Nalepa 1991; Barton and Anholt 1997) have questioned whether contaminants play a role in the distribution and abundance of benthic organisms. Others have noted evidence of elevated

concentrations of heavy metals and organic contaminants in sediment cores from the open lake compared to pre-settlement times, and documented the importance of the Niagara River as a source of contaminated sediments (Rang *et al.* 1992). Accumulation of contaminants does take place in some benthic organisms, having been found in *Diporeia* in western Lake Ontario (Environment Canada *et al.* 1998a). Sport fish consumption guidelines recognize the presence of toxic contaminants in fish flesh, and may provide one barometer of progress in this area.

Further assessment of the degradation of benthos by contaminants will be included in subsequent stages of the Lake Ontario LaMP, along with analysis to more clearly differentiate contaminant influences from those of physical habitat, predation, and nutrient levels.

Exotic Species

Exotic species almost completely dominate offshore communities and their management, but additional new exotics may threaten biodiversity further.

As outlined previously, the offshore fish communities are almost completely dominated by exotic species, and both pelagic and benthic plankton and invertebrate communities are also strongly influenced by the impacts of exotics. Nonetheless, a major future threat to the biodiversity of this community remains the unintentional introduction of new species via stocking programs, aquaculture, water diversions, navigation channels, and shipping (Stewart *et al.* 1999).

The potential for expanded impact by exotic species is considerable. Species already introduced into the Great Lakes, such as ruffe, have not yet established themselves in Lake Ontario. Other species, notably zebra and quagga mussels, continue to increase in abundance. Further declines in rainbow smelt and alewife populations may provide opportunities for new exotics to colonize and expand (Stewart *et al.* 1999). The abundance of a relatively recent zooplankton species, the spiny water flea, has been correlated with reduced alewife predation in the past (Johannsson *et al.* 1991), suggesting that it or other non-native species could respond to declining alewife numbers.

One of the management dilemmas for Lake Ontario fisheries is that the artificial structure of non-native large salmonids, supported by non-native prey-fish, has become so established as to support a considerable sport-fishing industry. In developing their fish community objectives for the Lake, the LOC struggled with the question of stocking further salmonids at levels likely to be unsustainable in the face of changing lake conditions, in order to meet the demands of sport fishing stakeholders. In the end, the LOC chose to support relatively high levels of trout and salmon abundance without putting excessive predatory pressure on alewives, even though this decision may impede progress towards objectives to rehabilitate native species (Stewart *et al.* 1999).

5.5 Summary of Impairment, Information Gaps, and Emerging Issues

- Nutrient concentrations have declined to stable levels that no longer threaten offshore habitats in Lake Ontario.
- Offshore pelagic fish communities have become very unstable in response to changing habitat conditions and predator-prey relationships, while offshore benthic fish communities have shown some recent improvement.
- Offshore plankton are shifting in community structure and abundance in response to phosphorus reductions and mussel invasion.
- The abundance of benthic organisms in offshore areas has declined significantly since the 1960s, and major changes in species composition have occurred recently.
- The recent invasion of zebra and quagga mussels to Lake Ontario has had major ramifications throughout the aquatic ecosystem which have not yet been fully felt and which are likely to impact on future fish and plankton populations in uncertain ways.
- Exotic species now almost completely dominate offshore communities and their management, and additional species introductions have the potential to further threaten biodiversity.
- The role of toxic contaminants in the offshore benthic environment needs further assessment.

6.0 Overview of Current Habitat Rehabilitation Efforts

Over the past ten years, a large number of habitat rehabilitation projects have been carried out in the Lake Ontario watershed, many of them in association with Remedial Action Plans (RAPs). Remedial Action Plans are currently underway for the Bay of Quinte, Port Hope Harbour, Toronto and Region, and Hamilton Harbour. The Niagara River RAP, which includes the Welland River watershed, also has a strong link to the health of Lake Ontario (Environment Canada and Ontario Ministry of the Environment 1999).

One of the most striking features of rehabilitation projects is the number and complexity of partnerships in their design, funding, and implementation. In many cases, a number of different programs are participating in the same projects, which adds to their likelihood of success but can make it difficult to fully credit all partners in summarizing their impact. In this section, projects are usually listed once, but readers are asked to remember that a wide range of other program partners are usually involved.

The RAP associated with each project is listed as NR for Niagara River, HH for Hamilton Harbour, TO for Toronto and Region, and BQ for Bay of Quinte. In some cases, the RAP teams sponsored the projects directly; in other instances, the project is simply located within a RAP's boundaries.

Interesting Web Sites:

Great Lakes Wetlands Conservation Action Plan
http://www.on.ec.gc.ca/green-lane/wildlife/glwcap/

Great Lakes 2000 Cleanup Fund
http://www.on.ec.gc.ca/green-lane/cuf/

EcoAction 2000
http://www.on.ec.gc.ca/ecoaction/home.html

Lake Ontario Lakewide Management Plan
http://www.on.ec.gc.ca/glimr/lakes/ontario/intro.html

Ontario Ministry of Natural Resources
http://www.mnr.gov.on.ca/MNR/

Ontario Streams
http://www.ontariostreams.on.ca/

Wetland Habitat Fund
http://www.wetlandfund.com/

Ontario Great Lakes Renewal Foundation
http://www.greatlakes.on.ca/

Ducks Unlimited Canada
http://www.ducks.ca

Lake Ontario Waterfront Trust
http://www.waterfronttrail.org/

Watershed Report Card
http://www.watershedreportcard.org

6.1 Great Lakes Wetlands Conservation Action Plan

The Great Lakes Wetlands Conservation Action Plan (GLWCAP) is a cooperative program involving federal and provincial governments and non-government organizations in efforts to create, reclaim, rehabilitate and protect wetland habitat in the Great Lakes basin. During its first phase, from 1994 to 2000, GLWCAP focused on coastal wetlands of the Lower Lakes and adopted eight strategies for working towards those goals:

- increase public awareness and commitment to the protection of wetlands;
- develop a wetlands database and an increased understanding of wetlands dynamics;
- secure wetlands;
- create, reclaim and rehabilitate wetlands;
- strengthen legislation, policies, agreements and compliance;
- strengthen local planning and commitment to protecting wetlands;
- improve coordination and planning among government and non-government organizations; and
- evaluate the program (Environment Canada *et al.* 1997).

Among the key GLWCAP project areas for Lake Ontario wetlands have been:

- Stoney Creek Marsh near Hamilton (HH);
- Cootes Paradise in association with the Hamilton Harbour RAP (HH);
- a series of waterfront and lower Don valley rehabilitation projects in association with the Toronto and Region RAP (TO);
- Oshawa Second Marsh, in cooperation with Friends of Second Marsh and the City of Oshawa;
- Wesleyville Marshes west of Port Hope;
- several Bay of Quinte wetlands in association with the Bay of Quinte RAP (BQ); and
- two Kingston-area wetlands.

GLWCAP is a key delivery mechanism for the goal of rehabilitating and protecting 6 000 hectares of wetland habitat by the year 2000, as set out in the *Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem.* A recent review of its progress has just been completed (Environment Canada *et al.* 2000), which provides highlights of progress towards GLWCAP's goals. Planning for a second Action Plan is currently underway by GLWCAP's implementation team and other partners.

6.2 Great Lakes 2000 Cleanup Fund

Over the past ten years, the Great Lakes 2000 Cleanup Fund has provided financial assistance to projects that increase biodiversity, support rehabilitation, and encourage community empowerment (see "Interesting Web Sites", page 103 for further details) . This program was terminated on March 31, 2000 and has been succeeded by the Great Lakes Sustainability Fund (see page 108) . Within the Lake Ontario watershed, these projects can be grouped into four categories:

1. **Wetland rehabilitation** (sometimes also including upland or shoreline components):
    - hydrology/hydrogeology study for habitat rehabilitation of Willoughby Marsh (NR);
    - Martindale Pond/Henley ecosystem management plan (NR);
    - eight large habitat rehabilitation projects in Cootes Paradise and Hamilton Harbour (HH);
    - coastal wetlands rehabilitation in Humber River marshes, Highland Creek wetland complex, Toronto Island wetlands, and Rouge River marshes (TO);
    - creation of Chester Springs marsh, Don Valley Brickworks wetland, and other small rehabilitation projects in Toronto's lower Don valley (TO);
    - wetland/fish habitat rehabilitation at Toronto Islands, Scarborough Bluffers Park, Ashbridge's Bay, and Etobicoke's Mimico Creek mouth (TO);
    - rehabilitation of natural habitat structure at Humber Bay Park East and Colonel Samuel Smith Park (TO);
    - habitat linkage and fish spawning enhancement at Tommy Thompson Park (TO);
    - wetland rehabilitation at Oshawa Second Marsh;
    - landowner contact, tree planting, and habitat rehabilitation assistance in Bay of Quinte watershed (BQ);
    - shoreline naturalization and wetland creation in East Bayshore Park, Belleville (BQ); and
    - wetland rehabilitation in Sawguin Creek Marsh, Bay of Quinte (BQ)
2. **Stream or riparian habitat enhancement:**
    - more than fifty agricultural improvement projects riparian fencing, tree planting, manure management in the Welland River watershed (NR);

- watershed stewardship with 1 400 landowners in Hamilton Harbour watershed, including over 100 rehabilitation projects (HH);
- removal of weirs blocking fish access in Centennial Creek (TO);
- habitat rehabilitation and removal of stream obstructions in East Humber River (TO);
- removal of Palgrave Dam and coldwater habitat rehabilitation on Humber River (TO);
- tree and shrub planting and rehabilitation planning in Sun Row Park on the lower Humber River (TO);
- redesign of Pottery Road weirs to allow fish access to Don River (TO);
- redesign of a water quality pond in Harding Park in upper East Don watershed (TO);
- rehabilitation of aquatic habitat in the Morningside Tributary of the Rouge River (TO);
- creation of a fish by-pass around Toogood Pond on Rouge River (TO);
- enhancement of coldwater fish habitat in Rouge River headwaters (TO);
- redirection of water flow from an unused spring into a tributary of Robinson Creek, Rouge River (TO);
- replacing a concrete channel with naturalized wetlands and floodplain on a tributary of the Don River in Terraview Park and Willowfield Gardens Park in Scarborough (TO);
- three hundred and fifty remediation projects in selected Bay of Quinte watersheds, including livestock restrictions, no-till agriculture, and updating of rural septic systems (BQ); and
- removal of a retaining wall and shoreline naturalization along the Trent River (BQ).

3. **Strategic planning studies:**

- examination of options for restoring physical and ecological stability to the Welland River (NR);
- habitat target strategy for Niagara River wetlands (NR);
- developing a Greenlands Strategy for Hamilton-Wentworth Region (HH);

- testing forest cover habitat targets for the Hamilton Harbour (HH) and Humber River watersheds (TO);
- watershed study for Grindstone Creek (HH);
- defining nine management zones within a fisheries management plan for the Humber River (TO);
- assigning conservation priorities to terrestrial fauna species in the Toronto and Region Area of Concern (TO);
- evaluating fish communities in Etobicoke and Mimico Creeks (TO);
- examining opportunities for greater fish access to the Don River (TO);
- state-of-the-watershed reports for the Don River, Etobicoke and Mimico Creeks (TO);
- developing a Remediation Strategy for Wilcox Lake in the Oak Ridges Moraine (TO);
- proposing rehabilitation options for High Park and Grenadier Pond (TO);
- habitat evaluation and multi-stakeholder strategic plan development for Bay of Quinte shoreline (BQ);
- planning for habitat rehabilitation targets and specific populations (black tern, lake sturgeon, least bittern) in Bay of Quinte (BQ);
- reviewing phosphorus loading targets and role of zebra mussels in Bay of Quinte (BQ);
- aquatic bio-assessment of five agricultural sub-watersheds in Bay of Quinte area (BQ); and
- planning for lake sturgeon recovery in Bay of Quinte (BQ).

4. **Shoreline habitat rehabilitation:**

- construction of three islands in Hamilton Harbour for colonial waterbirds (HH);
- construction of floating vegetated rafts for black terns in Cootes Paradise (HH);
- installation of floating wooden reefrafts in Tommy Thompson Park, Frenchman's Bay and Duffins Creek marsh (TO); and
- placing of osprey and bald eagle platforms and peregrine falcon nest boxes to help restore breeding populations of raptors throughout the basin.

6.3 Great Lakes Sustainability Fund

The Great Lakes Sustainability Fund (GLSF), formerly known as the Great Lakes 2000 Cleanup Fund, is a component of the Great Lakes Basin 2020 Action Plan. This plan, led by Environment Canada in partnership with eight Government of Canada departments, aims to complete the required rehabilitation of beneficial uses in 13 Areas of Concern (AOCs) and aid in making significant progress in the remaining three AOCs. Funding will be provided to initiatives that are essential to the rehabilitation of currently impaired beneficial uses. Projects may include habitat rehabilitation, contaminated sediment remediation, stewardship, and control of urban and rural runoff.

6.4 Action 21/EcoAction 2000 Projects

Environment Canada's Action 21 program, which was later replaced by the EcoAction 2000 program, provides support to habitat rehabilitation projects sponsored by local community groups. Usually these projects include a high degree of volunteer involvement, focus on community capacity building and offer important educational benefits as participants "learn by doing". Table 16 provides a synopsis of projects supported in the Lake Ontario watershed from 1995 to 1999, and the types of habitat involved in each.

Table 16: Action 21 / EcoAction 2000 projects in the Lake Ontario watershed

Project	Riparian/ Watershed	Wetland/ Shoreline	Endangered Species/ Community	Urban Habitats	Environment Monitoring
Urquhart Butterfly Garden (HH)				✓	
Black Creek Watershed (TO)	✓			✓	
Endangered/Threatened Birds Recovery			✓		✓
Little Rouge Restoration (TO)	✓				
School Ground Naturalization				✓	
Toronto Watershed (WEIP) (TO)	✓			✓	
Hamilton Watershed Stewardship (HH)	✓			✓	
Korean Community Trees (TO)				✓	
Rouge Valley Tree Planting (TO)	✓				
Niagara Escarpment Outreach					✓
Lower Don Nursery and Planting (TO)	✓			✓	
Alex Wilson Garden (TO)				✓	
Second Marsh Watershed Stew.	✓	✓			
Over the Fence Toronto Annex (TO)				✓	
Youth Greening Rouge (TO)	✓				
Lower Don Community Stew. (TO)	✓			✓	
Working for Wilderness		✓			
LEAF Toronto (TO)				✓	

Project (cont.)	Riparian/ Watershed (cont.)	Wetland/ Shoreline (cont.)	Endangered Species/ Community (cont.)	Urban Habitats (cont.)	Environment Monitoring (cont.)
Camp Weselka Pond Rehab. (TO)		✓			
Housing for East York Birds (TO)				✓	
Mainstream's Naturalization (NR)				✓	
Caring for Black Cr. Watershed (TO)	✓			✓	
Multi-Cultural Stewardship (TO)	✓	✓		✓	
Baden-Powell Prairie-Savannah (NR)			✓	✓	
Where Edges Meet Community Stew.				✓	
Quinte Shoreline Naturalization (BQ)		✓			
Endangered Birds Recovery			✓		
Otonabee Healthier Shores		✓			
Bartley Smith Greenway (TO)	✓				
Frenchman's Bay Rehabilitation	✓	✓			
Festive Earth - Riverdale (TO)	✓			✓	
Kids Can St. Catherines (NR)				✓	
Terraview Wetland - Scarborough (TO)	✓	✓		✓	
Osprey Nest Platforms (BQ)		✓			
Milne Hollow Rehabilitation (TO)	✓	✓		✓	

Project (cont.)	Riparian/ Watershed (cont.)	Wetland/ Shoreline (cont.)	Endangered Species/ Community (cont.)	Urban Habitats (cont.)	Environment Monitoring (cont.)
Brampton River Flood Lands	✓				
Highland Creek Markham Road (TO)	✓				
Black Creek Restoration (TO)	✓				
Little Cat River Restoration	✓				
Rouge Valley Wildlife Habitat (TO)	✓				
Peregrine Project Release (TO)			✓		
TO Waterfront Naturalization (TO)		✓			
Grassy Brook Aquatic Rehab. (NR)	✓				
New Canadians Greener Don (TO)	✓				
Credit River Rehabilitation	✓				
Little Rouge River Rehabilitation (TO)	✓				
Humber Savanna Project (TO)			✓		
Lower Grindstone Cr. Rehabilitation (HH)	✓	✓		✓	
Credit R. Rehab. Phase 3	✓			✓	
Clean the Creek Program (TO)	✓			✓	
Trees 2000: Halton Region				✓	

Data Source: Environment Canada, EcoAction 2000, 2000

6.5 Other Habitat Rehabilitation Programs

A number of other agencies and organizations take part in various kinds of habitat rehabilitation within the Lake Ontario watershed. These include:

- The Ontario Ministry of Natural Resources (OMNR) supports a large number of community-level projects, usually at a relatively small scale, through its Community Wildlife Involvement Program (CWIP) and Community Fisheries Involvement Program (CFIP). As well, OMNR has been active in coldwater stream enhancement projects in such sites as Wilmot Creek and Shelter Valley Creek.

- OMNR is usually a lead partner in the development of fisheries management plans, watershed plans, and natural heritage strategies, in conjunction with conservation authorities and municipalities. Fisheries management plans, or watershed action plans with a significant fisheries component, have recently been developed or are in process for Stoney Creek, Red Hill Creek, Spencer Creek, Grindstone Creek, Joshua Creek, Sixteen Mile Creek, Credit River, Etobicoke/Mimico Creek, Humber River, Don River, Highland Creek, Rouge River, Duffins Creek, Bowmanville Creek, Soper Creek, and Wilmot Creek.

- Thirteen Lake Ontario conservation authorities have been active for many years in rehabilitation programs in riparian areas (e.g., streambank erosion control) and tree-planting, and in recent years have become increasingly involved in working with landowners on rehabilitation projects through stewardship programs. Conservation authorities play a leading role in the implementation of RAPs, and in naturalization projects along watercourses and the Lake Ontario shoreline. In some cases, municipalities also become directly involved in habitat rehabilitation projects on municipally-owned lands.

- Tree planting programs previously offered by both the OMNR and various conservation authorities have been largely abandoned. Project Tree Cover, offered by the Ontario Forestry Association in cooperation with conservation authorities, is funded largely through corporate and individual donations. It provides site preparation, planting, and one tending operation for a fixed cost.

- The Wetland Habitat Fund, supported by Wildlife Habitat Canada, OMNR, and other partners, encourages and supports private landowners in their efforts to conserve and enhance existing wetlands on their properties. Habitat projects that enhance wetland habitat diversity and benefit waterfowl may be eligible for funds up to a maximum of 50 percent of the project costs or $5 000. Regional representatives provide advice and assistance to applicants, who develop a Wetland Conservation Plan. Approximately 75 wetland enhancement projects have been completed within the Lake Ontario watershed in the 1998 to 2000 period (L. O'Grady pers. comm.).

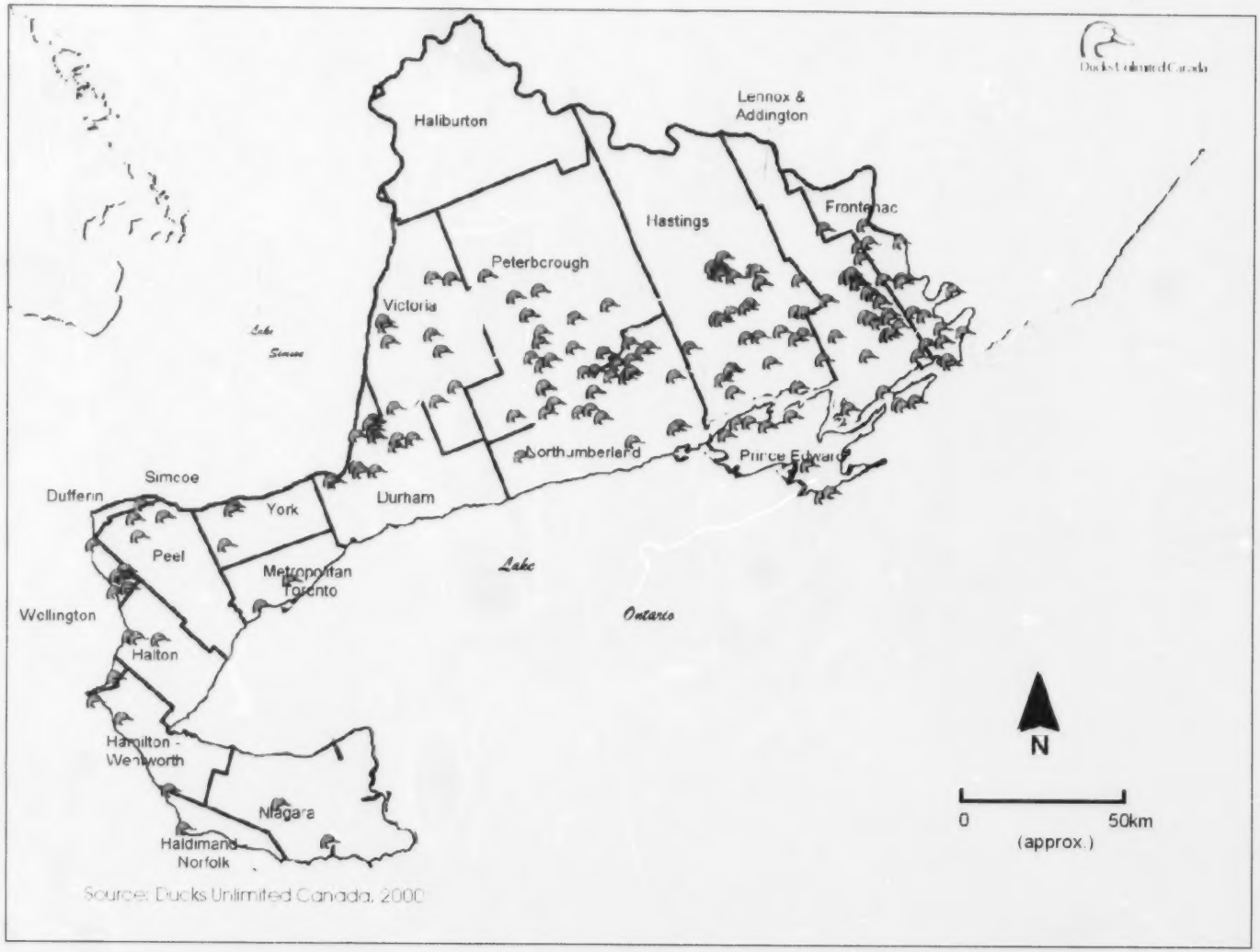
- Watershed report cards have been used by community groups as a planning tool in the watersheds of Waring Creek, Salem Creek, Ganaraska River, and Humber River. This process helps identify and assess rehabilitation needs and opportunities, and is likely to be used in other watersheds in the future.

- Many non-government organizations are involved in the promotion and implementation of tree planting, such as Earth Day Canada, Friends of the Earth, Evergreen Foundation, and 10,000 Trees for the Rouge. Most of these activities are oriented towards urban areas, and provide valuable consciousness-raising benefits as well as habitat enhancement.

- A variety of non-government interest groups such as Trout Unlimited, Ontario Streams, Valleys 2000 (Bowmanville), and local rod and gun clubs undertake stream rehabilitation work on a site-specific basis. Often these rehabilitation projects are guided by the Community Fisheries Involvement Program Manual developed by the OMNR.

- The largest non-government programs related to wetlands rehabilitation are delivered by Ducks Unlimited Canada, often on behalf of the partners in the Eastern Habitat Joint Venture (Ontario) of the North American Waterfowl Management Plan including: the Ontario Ministry of Natural Resources, Environment Canada (Canadian Wildlife Service), Ducks Unlimited Canada, Wildlife Habitat Canada, The Nature Conservancy of Canada, Ontario Ministry of Agriculture, Food and Rural Affairs, and Agriculture and Agri-Food Canada. Ducks Unlimited develops long-term agreements with public or private landowners and undertakes a variety of wetland enhancement projects. Projects undertaken within the Lake Ontario Watershed from 1977 to 1999 are shown in figure 37.

Figure 37. Ducks Unlimited Canada and Eastern Habitat Joint Venture of the North American Waterfowl Management Plan projects in the Lake Ontario watershed between 1977 and 1999



6.6 Agricultural Programs

Several federal-provincial programs related to sustainable agriculture were developed under the Canada-Ontario Agriculture Green Plan, and are being implemented through farm groups and coalitions.

The Environmental Farm Plan program was developed by a coalition of major farm associations, and is being delivered through local chapters of the Soil and Crop Improvement Association. Individual farmers are encouraged to assess environmental issues in their operations, including the health and management of natural areas, through workshops and completion of a workbook covering 23 subjects. Within a few years, it is hoped that all farm operations will have completed an environmental farm plan. A small amount of funding is also available to farmers to address priority areas identified in their plans.

Another project which included participation from both the federal and provincial governments, the Ontario Federation of Agriculture and other partners was the development of Best Management Practices booklets, which are designed to help farmers improve productivity, meet business goals, and protect soil, water, and other natural resources. This series includes booklets on *Farm Forestry* and *Habitat Management, Water Management,* and *Wildlife Management.*

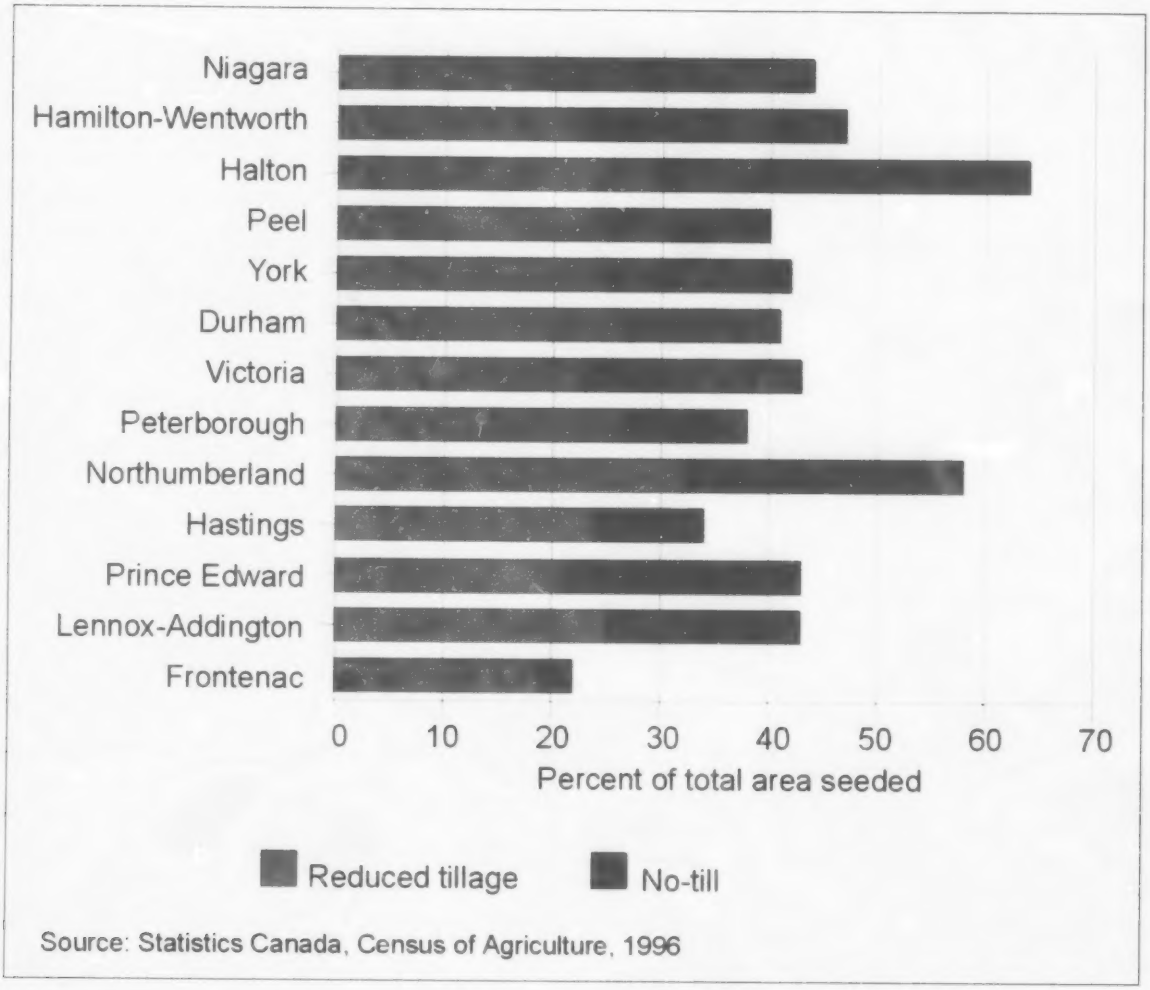
The Stewardship Information Bureau, based in Guelph, Ontario, provides an information network to farmers and others on agricultural practices that protect the environment. The network communicates both electronically and through printed publications.

The Rural Conservation Clubs and Wetland/Woodlands/Wildlife Program have funded programs which promote and demonstrate practices to enhance the rural environment and reduce conflicts between agriculture and the natural environment. For example, the Agriculture Diffuse Source Control Strategy in the Bay of Quinte watershed established 25 demonstration sites in partnership with farming landowners. These included such projects as restricting livestock from riparian habitat, improved manure storage, milkhouse washwater disposal and treatment, domestic sewage system updates, implementing no-till and reduced tillage practices, and retirement of fragile crop land next to watercourses. Currently, this strategy/project is delivering a planting and land stewardship program promoting increased protection and canopied forest cover in two selected Bay of Quinte watersheds.

Ducks Unlimited Canada offers another cooperative program, Ontario LandCARE (Conservation of Agriculture, Resources and Environment), a key Eastern Habitat Joint Venture-funded stewardship program , which provides financial assistance for grazing management, permanent cover and buffers, forage management, and water management.

One significant remediation technique that can be undertaken by farmers is the use of reduced tillage or no-till, since this reduces the amount of eroded sediment and attached nutrients and pollutants that wash off into stream habitats. Figure 37 provides a summary of the use of this technique in the mid-1990s.in Figure 37.

Figure 38. Use of reduced tillage and no-till*



* No data are available for Toronto and Haliburton counties.

6.7 Summary Assessment of Habitat Rehabilitation Programs

The majority of rehabilitation programs relate to wetlands, especially marshes and other wetlands along the Lake Ontario shore. Another large group of rehabilitation projects involve streams and riparian zones, especially those in urban or near-urban areas, and often involve tree-planting or wildlife habitat rehabilitation. Large-scale tree-planting programs in rural areas have mostly fallen victim to budget cuts in government agencies, and the extent of tree-planting on private lands is currently much lower than in previous decades. Agricultural programs are widespread and appear to be having some positive effect; a wide range of agricultural programs and information has been developed but sustaining these programs in the future is uncertain. There is a very broad mix of government and non-government activity in habitat rehabilitation, but the projects being undertaken are often uncoordinated, small-scale, and opportunistic at the present time.

7.0 Overview of Current Habitat Conservation Efforts

Habitats within the Lake Ontario basin are being conserved in many ways through establishment of parks and protected areas, through a variety of planning approaches, through private land stewardship, and through monitoring activities to identify concerns and progress. This section provides a brief snapshot of these activities.

7.1 Parks and Public Lands

Protected areas in the Lake Ontario watershed come in several forms:

- The Trent-Severn Canal, part of the National Parks system, incorporates a variety of lands and waters in the immediate vicinity of the canal and its locks.

- The Ontario Parks system, part of the Ontario Ministry of Natural Resources (OMNR), includes eight natural environment parks, eight recreation parks, three nature reserves, and two historical parks within the watershed, as outlined in Table 17.

Table 17: Provincial Parks in the Lake Ontario watershed

Natural Environment	Recreation	Nature Reserve	Historical
Presqu'ile Sandbanks Short Hills Indian Point Wolf Island Silent Lake Kawartha Highland Bon Echo	Bronte Creek Darlington Emily Mark S. Burnham Balsam Lake Ferris North Beach Lake on the Mountain	Peter's Woods Stoco Fen Timber Island	Serpent Mounds Petroglyphs

- The Ontario Living Legacy program has recently announced the establishment of four provincial parks or additions and six conservation reserves within the watershed. These new areas will be regulated over the next several years and will add nearly 50 000 hectares of protected area within the Lake Ontario watershed (Ontario Ministry of Natural Resources 1999a).

- Over half of the watershed area on the Canadian Shield is provincial Crown land, most of which is managed for commercial forestry under a system of Sustainable Forest Licenses, which includes consideration for habitat values through stream setbacks, protection of nesting sites and rare species, and modified management in valuable habitat areas.

- A few national and provincial wildlife areas are located within the watershed, including the Prince Edward Point and Wellers Bay National Wildlife Areas, and the Point Petre, Nonquon, and Brighton Provincial Wildlife Areas.

- The 13 conservation authorities within the watershed collectively own almost 36 000 hectares of land, which are managed for habitat values, floodplain protection, resource management, and recreation. Conservation lands are particularly focused on the Niagara Escarpment and on wetland and valley land sites across the region.

- Many of the counties and regions have extensive County/Regional Forests, particularly along the Oak Ridges Moraine. Most of these forest areas are managed for logging as well as for their soil protection and habitat functions. Many of them are conifer plantations.

- A variety of other agencies own natural landscapes and manage them for habitat protection. For example, the Ontario Heritage Foundation has natural properties at Scotsdale near Georgetown, Fleetwood Creek in the Peterborough area, and Barnum House near Grafton. Significant parts of Cootes Paradise are owned by the Royal Botanical Gardens. The Niagara Parks Commission owns natural areas along the Niagara River. The Rouge Park, on the eastern edge of Toronto, has a mix of landowners and is managed jointly by a committee created for that purpose.

To judge the adequacy of these protected areas to provide a base to sustain the full range of species and communities in the Lake Ontario watershed, their distribution is compared to landscape units called "enduring features" mapped by World Wildlife Fund Canada. This analysis uses a series of criteria related to the size of each protected area, the types of land uses prohibited within each, and its permanence. Groups of enduring features make up "site districts", which reflect broader landscape patterns (see Figure 4, page 7). Within the Lake Ontario watershed, the World Wildlife Fund Canada representation assessment for eight Site Districts is summarized in Table 18.

Like most areas of southern Ontario, the Lake Ontario watershed is seriously deficient in representative protected areas. When they are regulated, the new Ontario Living Legacy sites will provide additional representation in Site District 5E-11, but will not affect the others.

Several programs identify priority sites for land acquisition in the Lake Ontario watershed. The Eastern Habitat Joint Venture (EHJV) for Ontario is part of the international North American Waterfowl Management Plan, which seeks to secure waterfowl resources by maintaining and enhancing the abundance and quality of wetlands. In its *Implementation Plan for Ontario,* EHJV identifies Lake Scugog, Presqu'ile, Amherst Island, and Wolfe Island among its priority habitats for securement. Under the Great Lakes Wetlands Conservation Action Plan (GLWCAP), two additional sites, Westplain Mud Lake and Big Sandy Bay, are identified as securement projects. Other priority wetland sites for future securement include Oshawa Second Marsh, West Side Creek marsh, Wellers Bay wetland, Huyck's Bay wetland, West Lake wetland, Cataraqui marshes, Big Island marsh, and Fish Lake wetland.

The provincial government, through its Natural Areas Program, has provided acquisition funding for three areas: Niagara Escarpment, Rouge Valley, and Lynde Creek Marsh. While funding constraints have reduced their level of activity, some conservation authorities still maintain active land acquisition programs as well.

Table 18: Enduring feature representation in the Lake Ontario watershed

Site District*	Landscape Types	Degree of Representation
7E-3 Niagara	Mix of morainal till, fluvial and lacustrine soils, mostly fine-textured	2 units with partial representation; 5 units with little or none
7E-4 Toronto-Oakville	Morainal till materials with fine to medium-texture soils	3 units with partial representation
6E-7 Oak Ridges Moraine	Mostly morainal till, with some medium-texture glacio-fluvial soils	2 units with partial representation; 7 others with little or none
6E-8 Peterborough Drumlin Field	Mostly morainal till, mixed with some fine-textured lacustrine soils	2 units with partial representation; 7 others with little or none
6E-13 Lake Ontario Plain	Mix of medium-textured lacustrine and till soils	4 units with partial representation; 6 others with little or none
5E-11 Southern Shield	Mix of acidic bedrock, morainal till, bogs, some lacustrine deposits	Largest unit has moderate representation; 2 units with partial; 4 units with little or none
6E-9 Dummer Moraine	Mostly morainal till and mixed soils with medium/ coarse soils	1 unit with partial representation; 6 others with little or none
6E-15 Prince Edward-Napanee Plain	Mix of fine-textured till and lacustrine soils over shallow limestone bedrock	1 unit with moderate representation; 2 units with partial; 5 units with little or none

Data Source: T. Iacobelli pers. comm.

* Haldimand clay plain (Site District 7E-2) has not been included here since very little of the district is found in the Lake Ontario watershed

Donation of ecologically sensitive lands and conservation easements is an important mechanism for securing some sites, depending on the willingness of landowners and the presence of an organization to accept donations. Some land donations are directed towards conservation authorities or Crown agencies such as the Ontario Heritage Foundation. Increasingly, non-government organizations such as The Nature Conservancy of Canada (NCC), Federation of Ontario Naturalists (FON), or local land trusts are the recipients of donated lands or easements.

The federal government has provided income tax incentives for the donation of ecologically sensitive lands, which were recently upgraded by a provision for lower capital gains taxes on these donations. Over the past three years, thirteen land donations and nine conservation easements have been accepted under the Ecological Gifts Program within the Lake Ontario watershed, totaling 760.3 hectares.

7.2 Planning Initiatives

Municipal Plans and Environmentally Significant Areas

While planning at the local and regional municipality level provides the primary set of land use controls in Ontario, all municipal plans must have regard for provincial policies. A new provincial Natural Heritage Policy took effect in 1995, as part of the Provincial Policy Statement under the *Ontario Planning Act.*

These policies must be incorporated into new or updated municipal Official Plans. Application of the policies is guided by a *Natural Heritage Reference Manual* (Ontario Ministry of Natural Resources 1999b). Presently there is considerable inconsistency in how natural heritage concerns are treated within Official Plans in the Lake Ontario watershed. Even where natural areas have been recognized as significant within an Official Plan, they are often zoned agricultural or hazard land, providing only partial protection from development activities.

Data on how well municipal Official Plans are protecting natural areas are not yet available on a widespread basis, although the provincial government does intend to monitor the effectiveness of their Planning Policies over the next several years. Within the Don River watershed, all eight municipalities have policies to protect ravines and stream valley corridors, but only five protect locally significant natural areas (Don Watershed Regeneration Council 1997).

Municipalities can also identify and protect natural areas beyond the scope of provincial policies. Environmentally Significant Areas (ESAs) are designated within municipal or watershed boundaries. Environmentally Significant Area studies have been carried out in most of the counties and regional municipalities in the watershed, in some cases through the conservation authorities (Table 19). However, they vary in quality and comprehensiveness. Some are outdated, having been compiled in the late 1970s. Others are fairly recent. The ESA study led by the Hamilton Naturalists' Club for the Hamilton-Wentworth area (Hamilton Naturalists' Club 1993) is an outstanding, detailed document. Other excellent recent studies have been completed in the Lower Trent area (Brownell and Blaney 1996) and along the Niagara Escarpment (Riley *et al.* 1998).

Provincial Natural Heritage Policy

"Natural heritage features and areas will be protected from incompatible development."

Natural heritage features and areas include the following:

- *provincially significant wetlands;*
- *fish habitat;*
- *significant portions of the habitat of endangered and threatened species;*
- *significant woodlands south and east of the Canadian Shield;*
- *significant valleylands south and east of the Canadian Shield;*
- *significant wildlife habitat;*
- *significant Areas of Natural and Scientific Interest (ANSIs); and*
- *biodiversity.*

The policy is applied in two parts:

1. Development and site alteration will not be permitted in significant portions of the habitat of endangered and threatened species, and in significant wetlands south and east of the Canadian Shield.

2. Development and site alteration may be permitted in fish habitat, in significant wetlands on the Canadian Shield, in significant woodlands south and east of the Canadian Shield, in significant wildlife habitat, and in significant ANSIs, if it has been demonstrated that it will not negatively impact the natural features or the ecological functions for which the area is identified.

The policy further states that development and site alteration may be permitted on adjacent lands to 1) and 2) if it has been demonstrated that it will not negatively impact the natural features or the ecological functions for which the area is identified. The diversity of natural features in an area, and the natural connections between them, should be maintained, and improved where possible.

Natural Habitats of Provincial Interest

Several types of natural landscapes have been identified for protective status both through provincial policies, as outlined above, and through provincial evaluation programs for specific sites. These include natural landscapes along the Niagara Escarpment, which are protected through the Niagara Escarpment Plan and a special commission. Wetlands across southern Ontario are evaluated through a consistent provincial evaluation process (Ontario Ministry of Natural Resources 1993); evaluated wetlands within the Lake Ontario watershed are shown in Figure 9 (page 20).

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Areas of Natural and Scientific Interest (ANSIs) are areas of land and water containing natural landscapes or features which have been identified by the OMNR as having values related to biodiversity conservation, natural heritage appreciation, scientific study, or education. A total of 256 provincially significant ANSIs have been identified within the Lake Ontario watershed; distributed as shown in Figure 39. These are classed as life science or earth science, depending on their ecological and geological values.

Since ANSIs are identified through landscape studies of Site Districts, with an emphasis on representing landform and ecological variability, they provide a good starting point for a comprehensive protection program. The OMNR seeks to protect provincially significant ANSIs where they occur on public lands, and through participation in the municipal land use planning process.

The Oak Ridges Moraine has been identified as a landform of provincial interest, and Interim Planning Guidelines for its protection were released by the Province of Ontario in 1991. A subsequent extensive planning process developed an Oak Ridges Moraine Strategy by 1994, but this document has not yet been endorsed by the Ontario government. Given the hydrological and habitat significance of the Moraine, and the large-scale urban developments that are threatening its integrity, public and municipal pressure is mounting for protective provincial action.

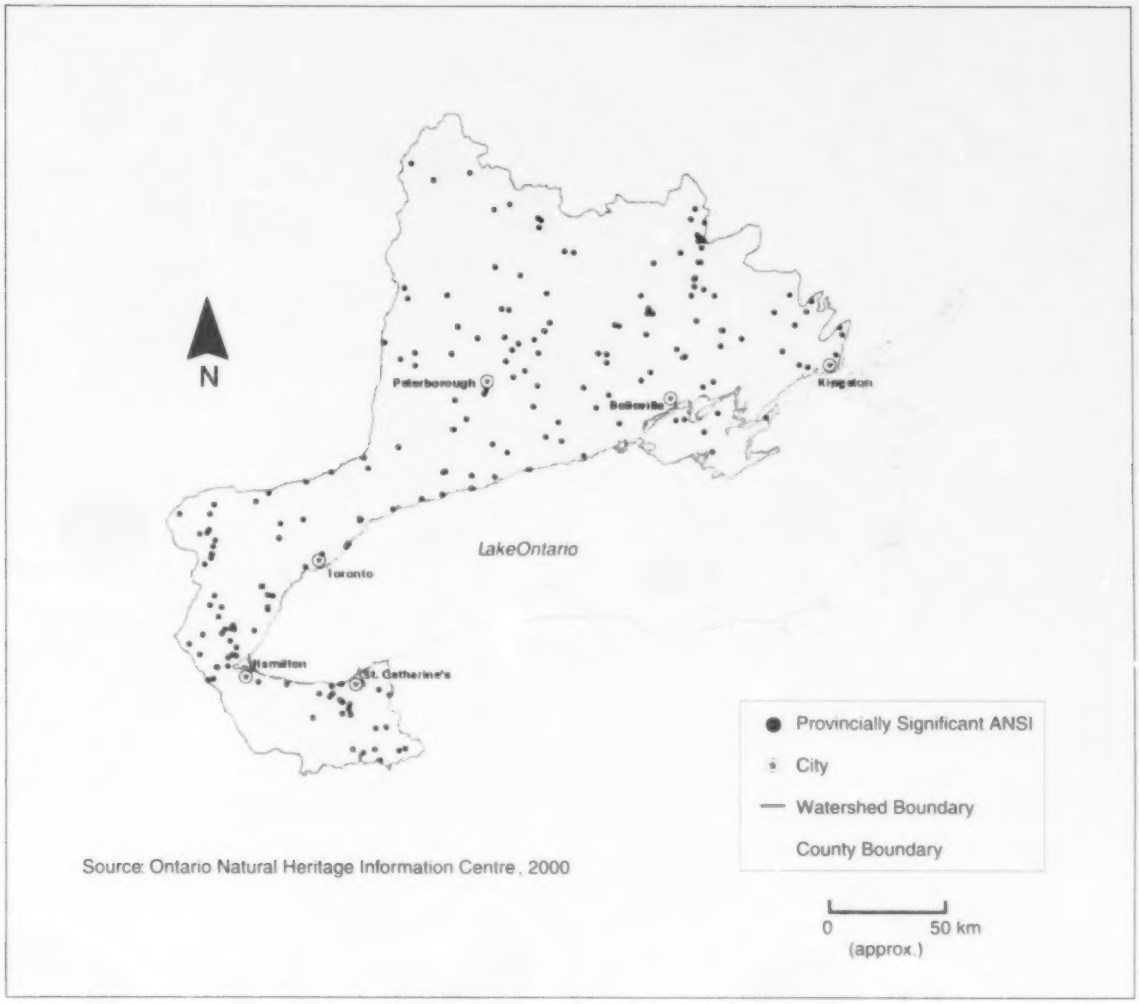
Along the Lake Ontario shoreline from Burlington to Trenton, the Waterfront Regeneration Trust has developed a comprehensive planning approach called the Lake Ontario Greenway Strategy (Waterfront Regeneration Trust 1995b). This Strategy addresses the protection and rehabilitation of physical, natural and cultural attributes of the shoreline area, promotes greater public understanding and recreational access, promotes compatible economic and employment opportunities, and fosters cooperation in public and private initiatives. Protection and rehabilitation of aquatic and nearshore terrestrial habitat are a core part of the Strategy.

Table 19: Environmentally Significant Area surveys in the Lake Ontario watershed

Municipality	Date	Level of Detail	Included in Official Plan
Niagara	1980 + Esc. Study*	low (high in Esc.)	yes
Hamilton-Wentworth	1994 + Esc. Study*	high	yes
Halton	1993 + Esc. Study*	med. (high in Esc.)	yes
Peel	1979 + Esc. Study*	low (high in Esc.)	yes
York	mid-1990s		yes
Toronto (TRCA)	1982 (being updated)	low	varies by jurisdiction
Durham	1978 (CLOCA)		
Victoria	N.A.		
Haliburton	N.A.		
Peterborough	N.A.		
Northumberland	1996 (Lower Trent CA)	high	
Hastings	1996 (Lower Trent CA)	high	
Prince Edward	N.A.		
Lennox & Addington	N.A.		
Frontenac	1996 (one township only)	high	yes

N.A. indicates that no ESA survey has been carried out
* indicates Niagara Escarpment study

Figure 39. Provincially significant Areas of Natural and Scientific Interest in the Lake Ontario watershed



Conservation Authority Programs

Conservation authorities are major owners of natural lands. They also influence the use of private lands within their watersheds, both directly through the implementation of *Fill, Construction and Alteration to Waterways* regulations in sensitive areas, and indirectly by providing input to municipal land use plans.

Conservation authorities provide direction for their activities through watershed plans; as shown in Table 20, these vary considerably in their age. As well, most conservation authorities are involved with more detailed subwatershed plans, particularly in urbanizing areas, which normally include measures to preserve or restore natural habitats. Some of the Lake Ontario conservation authorities have also developed shoreline management plans for their section of the coast, often in conjunction with municipalities (Lawrence 1995a, b).

Other Designations and Planning Processes

The Niagara Escarpment has been designated as a World Biosphere Reserve under the United Nations Man and the Biosphere Program. The long range goal of this program is to create a worldwide network of biosphere reserves to include examples of all the globe's main ecological systems with their different patterns of human use and adaptations to them.

Development activities within the Niagara Escarpment area are controlled by the Niagara Escarpment Planning and Development Act, which has the purpose of "providing for the maintenance of the Niagara Escarpment and the land in its vicinity substantially as a continuous natural environment". The Niagara Escarpment Plan includes protection for natural areas, and recently monitoring of cumulative environmental effects has been started (Geomatics International 1997).

Through the State of the Lakes Ecosystem Conference (SOLEC) in 1998, the concept of Biodiversity Investment Areas (BIAs) has been brought forward to recognize broad coastal areas that contain clusters of exceptional biodiversity values (Environment Canada and U.S. Environmental Protection Agency 1999). For the terrestrial nearshore area, a BIA extending eastwards from Presqu'ile Point to take in the shoreline of the Outlet basin has been described (Reid *et al.* 1999). Background work to identify wetland BIAs has been completed, with the identification of coastal eco-reaches with characteristic patterns of wetlands (Chow-Fraser and Albert 1998). Two coastal eco-reaches were identified on the Canadian side of Lake Ontario, with the division line at Presqu'ile.

A concept and preliminary identification of aquatic BIAs was also developed for SOLEC in 1998, based on aquatic habitats that are especially productive, support exceptionally high biodiversity, and contribute significantly to the integrity of the whole ecosystem (Koonce *et al.* 1998). Further work to integrate the three approaches and further refine this approach is underway.

A program which may in future be applied along the Lake Ontario coast is the designation of a National Marine Conservation Area (NMCA) by Parks Canada. As part of a national program to protect representative landscapes and seascapes across the country, each of the Great Lakes is

F3

to be represented by a NMCA by the year 2010. While some preliminary work has identified potential for a NMCA off the Prince Edward County coastline, this program is in its very early stages in Lake Ontario.

Table 20: Conservation authority lands, watershed plans, and shoreline plans

	Land Holdings (ha)	Watershed Plan/ Subwatershed Plans	Shoreline Management Plan
Niagara Peninsula	2 834	None	1994
Hamilton Region	3 576	Red Hill Creek 1998 Spencer Creek 1998	Stoney Creek 1981
Conservation Halton	598	Grindstone Creek 1998 Sixteen Mile Creek 1996 Bronte Creek 2000	Policy development in progress; environmental guidelines 1996
Credit Valley	2 521	Phase II 1990 Sawmill Creek 1993	1992
Toronto and Region	12 955	Don River 1994 Humber River 1997 Rouge River 1990	Integrated Shoreline Mgmt Plan: Scarborough 1996
Central Lake Ontario	1 211	Oshawa Creek 2000	1990
Ganaraska Region	6 073	Watershed Plan 1995 Wilmot Creek 1999	1990
Lower Trent	1 417	South Sidney 1995 Dead and York Cr. 1998	1990
Otonabee	1 629	None	N.A.
Kawartha	249	None	N.A.
Crowe Valley	607	None	N.A.
Quinte	1 642	None	1992
Cataraqui	2 201	Collins Creek 1994	N.A.

N.A. denotes not applicable i.e., no shoreline in conservation authority jurisdiction/watershed

The southwestern part of the Lake Ontario watershed falls within Carolinian Canada, and is part of an innovative conservation planning project called "The Big Picture: Cores and Connections in Canada's Carolinian Zone". This multi-agency effort, which has representation and technical input from more than 20 agencies and organizations, is designed to promote a long-term natural heritage vision for this zone. Detailed information is available from the Natural Heritage Information Centre in Peterborough or from the Carolinian Canada web site at http://www.carolinian.org.

7.3 Private Land Stewardship

Private land stewardship includes the careful safeguarding of natural habitats by landowners acting voluntarily. This might involve restricting activities such as logging from sensitive habitats or actively managing a property for particular species or habitats. Private land stewardship is usually carried out in partnership with conservation organizations or government agencies, who provide advice and incentives.

Within the Lake Ontario watershed, stewardship is often linked to landowner contact programs, which have included:

- extensive programs in the early 1990s sponsored by the Natural Heritage League and the OMNR, which provided personal visits to owners of provincially significant wetlands and Niagara Escarpment natural areas;
- information resources and cooperative habitat conservation and rehabilitation projects sponsored by Stewardship Councils established for each county or region by the OMNR;
- a multi-year watershed stewardship program sponsored EcoAction 2000 and delivered by Friends of Second Marsh for the Harmony Creek and Farewell Creek watersheds;
- a long-term program of landowner contact and habitat rehabilitation assistance within the watersheds feeding into Hamilton Harbour;
- contact with landowners in the Lower Trent watershed for sites surveyed during the Lower Trent Natural Areas Inventory; and
- extensive landowner contact to enlist participation in habitat enhancement and sediment control activities in the Bay of Quinte watersheds.

One incentive program for private landowners is the Conservation Lands Tax Reduction Program (CLTRP), which allows owners of provincially significant wetlands, ANSIs, endangered species habitats, and Escarpment natural areas to apply for an exemption on municipal property taxes. The amount of land involved and the participation of landowners is summarized in Table 21. The relatively small uptake on the program is due in part to overlap for some areas with farmland and managed forest tax reduction programs, to landowner reluctance to become involved with government programs, and to the relatively small dollar amounts involved in some cases.

Land trusts and other private conservation organizations have previously been able to qualify their lands under this program, but a 1998 moratorium on new applications has led to uncertainty about the future of this aspect of the CLTRP. However, negotiations to reinstate this section in the year 2000 appear promising.

Table 21: Participation in Conservation Lands Tax Reduction Program*

Municipality	Area Enrolled in CLTRP (ha)	Eligible Landowners Participating (#)
Niagara	2 487	1 111
Ham.-Wentworth	4 442	727
Halton	6 898	1 055
Peel	2 870	653
York	4 022	615
Durham	7 961	740
Victoria	11 995	817
Haliburton	360	42
Peterborough	10 894	908
Northumberland	3 314	406
Hastings	4 400	443
Prince Edward	1 468	186
Lennox-Addington	2 850	380
Total	**63 961**	**8 083**

* No data are available for Toronto and Frontenac counties

At the community level, stewardship with local landowners is often associated with a land trust, a nonprofit voluntary organization that encourages land or conservation easement donations and works cooperatively with landowners on conservation projects. The land trust community in Ontario is expanding rapidly, in part because of the assistance being provided by the Ontario Nature Trust Alliance. Within the Lake Ontario watershed, the following land trusts are currently active or in formation:

- the Hastings-Prince Edward Land Trust, which has identified the south shore of Prince Edward County as a special project area;
- the North Stoney Lake Land Trust, which works within the cottage community of Stoney Lake;
- Valleys 2000 (Bowmanville), which is undertaking a major rehabilitation project along Bowmanville Creek;

- the Kingston Field Naturalists club, who own several major sanctuaries in the Kingston region; and

- other land trust organizations which are in the process of formation in the Kawartha Lakes area, the Oak Ridges Moraine, the Northumberland-Brighton area, and possibly others.

7.4 Ecological Monitoring

Ecological monitoring allows resource managers and the public to identify emerging issues and to track progress in restoring ecosystems. An essential characteristic of monitoring is that it is recurring, so that changes over time can be compared. A wide range of monitoring programs are currently in place or proposed for Lake Ontario and its watershed, including:

- Federal and provincial toxics monitoring programs include the Ontario Ministry of the Environment (OMOE)/Ontario Ministry of Natural Resources Sports Fish Contaminant Monitoring Program, OMOE's contaminant monitoring of spottail shiners, Canadian Wildlife Service's (CWS) monitoring of contaminant levels in herring gull eggs, and OMOE's Large Volume Sampling in six Lake Ontario tributaries.

- Monitoring of changes in plankton and invertebrate communities within the Lake takes place through programs such as the BioIndex Program carried out until 1995 by the Department of Fisheries and Oceans, and the long-term OMOE monitoring of phytoplankton and related trophic and chemical parameters at water treatment plant intakes.

- Monitoring of physical characteristics of the environment include the Water Survey of Canada's long-term monitoring of tributary flow and suspended sediment levels, and Environment Canada's monitoring of lake level changes.

- Monitoring of population changes in fish communities occurs through monitoring of sport fish harvests for the Bay of Quinte and Lake Ontario, reporting of commercial fish catches and index fishing in the Lake and its tributaries, particularly in eastern Lake Ontario and Bay of Quinte.

- Some conservation authorities have adopted the Biological Monitoring and Assessment Program (BioMAP), developed by Griffiths (1993), to assess water quality in Lake Ontario watercourses. This program recognizes the sensitivity of various benthic macroinvertebrates to environmental stresses based on stream size.

- The Natural Heritage Information Centre's databases include information on rare species and communities, wetlands, ANSIs, and baseline vegetative data collected in the late 1960s and early 1970s on many significant natural areas through the International Biological Programme.

- A suite of monitoring indicators for the health of the Great Lakes ecosystem has been proposed through the SOLEC '98 process (Bertram and Stadler-Salt 1998), and will be gradually monitored as implementation programs are developed.

- Preliminary Lake Ontario Ecosystem Objectives were presented in the Lakewide Management Plan (LaMP) Stage 1 report (Environment Canada *et al.* 1998a). Indicators have been proposed to measure progress towards the objectives for wildlife, benthos and fish communities, and the LaMP will continue to work towards further development and implementation of these programs.

- Volunteer-based monitoring of bird and amphibian populations at wetland sites occurs through the Marsh Monitoring Program, a joint effort of Bird Studies Canada and Environment Canada. Road call counts and backyard surveys for amphibians are also used to monitor frog and toad populations across Ontario.

- A series of volunteer-based bird monitoring programs includes the Christmas Bird Count, Hawk Watching in the Niagara Peninsula, Toronto, and Whitby, Project FeederWatch, Breeding Bird Survey routes, Forest Bird Monitoring Program, nocturnal Owl Monitoring, and the Ontario Shorebird Survey. A comprehensive program, the Ontario Breeding Bird Atlas, was carried out in 1981 to 1985, and is scheduled to be repeated in the 2001 to 2005 period (Environment Canada 2000).

- Site-specific monitoring programs are associated with Remedial Action Plans (RAPs) and rehabilitation projects such as Oshawa Second Marsh. While these programs often yield valuable detailed data, there appears to be a need for improved coordination among programs so that results from one area can be compared to others.

7.5 Summary Assessment of Habitat Conservation Programs

While a mix of national and provincial parks, conservation areas, and other public lands protect significant habitats, the Lake Ontario watershed is deficient in protected areas to represent its full range of habitat types. Public acquisition of priority sites and tax incentives for donation of ecologically sensitive lands and conservation easements are important mechanisms, but are currently operating at a relatively low level of activity. Currently, there is considerable inconsistency in how natural heritage concerns are treated within municipal Official Plans and zoning practices. Provincially significant features including the Niagara Escarpment, Oak Ridges Moraine, and Lake Ontario waterfront, have been identified but the implementation of protective measures is generally weak. Conservation authorities are major land-holders within natural habitats, and their watershed and shoreline planning programs, while inconsistent across the Lake Ontario watershed, are valuable tools. Private land stewardship programs have been carried out in many rural parts of the watershed, and are increasingly being adapted for urban areas; landowner contact programs, conservation lands property tax incentives, and community-based land trusts are all significant components of these programs. A wide range of ecological monitoring programs are either currently in place or proposed, but coordination of monitoring efforts and analysis of resulting data is relatively weak.

8.0 Conclusions

Humankind has not been gentle to the ecosystem of Lake Ontario and its watershed. From this overview, it is clear that the lake and the lands that drain into it have seen a history of significant abuse since the time of European settlement. While the nature of the abuse has changed over the decades, and while the ecosystem has shown remarkable capacity to repair the damage, new forms of human-caused stress keep appearing. Habitats of the future are likely to be less rich in species and interactions, less resilient, and less able to endure further abuse unless ways are found which will provide some degree of relief from the cumulative effects of many different forms of stress on the ecosystem.

The history of Lake Ontario demonstrates that such relief would not be without precedent. Major environmental stressors of a generation ago, most notably nutrient enrichment and toxic contaminants, have been remarkably reduced. The lake ecosystem has responded, and populations of fish and wildlife once on the brink of extinction have rebounded.

Taken at a glance, the status and current stressors for each of the four broad habitat zones outlined in this report show a mix of progress in addressing past issues, but a daunting array of current challenges (Table 22).

Table 22: Summary of habitat status, trends, and stressors for habitat zones

	Watershed	***Tributaries***	***Nearshore***	***Offshore***
Current Habitat Status	*Significantly degraded*	*Significantly degraded*	*Significantly degraded*	*Mostly recovered*
Recent Trend	*Stable to declining*	*Stable on average*	*Partial recovery but unstable*	*Increasing instability*
Major Issues	*Forest loss and fragmentation; grassland and interior forest birds declining*	*Increasing flow variability; urban stormwater; dams*	*Limited supply of terrestrial habitats; shore hardening; zebra mussels*	*Non-native fish communities; rapid changes in benthic and pelagic life*
Significant Stressors				
Land Use Change	✓	✓	✓	
Physical Modifications	✓	✓	✓	
Toxic Contamination		✓	✓	✓
Exotic Species	✓		✓	✓
Climate Change	✓	✓	✓	

An examination of current rehabilitation programs reveals that they respond only partially to the significant stressors listed above:

- Programs to reduce phosphorus loadings to the lake have been very successful, particularly from point sources, but also from rural agricultural non-point sources. Since phosphorus targets have been met, these programs are less active than in the past.

- Programs to reduce contaminant loadings have also been successful, to the point where most of the priority toxics appear to no longer be affecting the viability and quality of aquatic habitats.

- Programs to rehabilitate tributary habitats are uneven and often inadequate, with most of the current attention being directed to tributaries within RAP watersheds, and insufficient strategic priority-setting within the Lake Ontario watershed as a whole.

- The majority of funding for rehabilitation projects has been directed to coastal wetland sites, with other major targets being riparian habitats and urban consciousness-raising. Relatively little funding has been directed towards rehabilitation of larger blocks of upland forest, although interest in that area is increasing.

- Recovery planning for individual species at risk or for communities at risk is at a very early stage, with a significant backlog of species and communities not yet addressed.

- While recent work has led to a better understanding of rehabilitation needs in such areas as urban streams and hardened shorelines, very little on-the-ground rehabilitation has taken place to date in these areas.

A significant array of habitat conservation programs are in place within the Lake Ontario watershed, and some programs such as public protected areas have had recent successes. In the agricultural and urban sections of the watershed, it is clear that public ownership of habitat areas will always be only a small part of the protection strategies needed. A mix of private land stewardship incentives and planning controls are essential to maintain future habitat distribution and quality. At present, those programs are only partially effective.

Two major factors could be viewed as "super-stressors" that have the potential to overwhelm much of the rehabilitation progress to date, and to seriously destabilize the Lake Ontario ecosystem.

The first, in the short term, is the ongoing invasion and expansion of exotic species, most notably zebra and quagga mussels. These organisms have had a profound, and likely permanent, effect, with impacts that are in the process of reverberating through the aquatic ecosystem and modifying both the community structure and the nature of the habitat itself. Some of their longer term effects are uncertain as yet, and it is possible that predation or other factors may bring some future balance to their populations.

Increasingly, Lake Ontario is dominated by non-native species, from fish communities to invertebrates, with a serious lack of ecological stability as a result. One consequence of this instability is vulnerability of the lake to invasion by even more exotics in future.

The second super-stressor, in the longer term, is the impact of climate change. If the current models are even partially correct, the terrestrial, tributary, and nearshore systems are likely to change significantly over the next century, and even the deepwater offshore systems will eventually be affected. Current protection and rehabilitation programs are not oriented towards the challenges posed by climate change, and new far-reaching responses will be necessary.

Based on these observations, the following needs have been identified:

1. The inter-connected nature of the lake ecosystem with its tributaries and watershed should continue to be recognized and stressed. In the past, the connections between watershed phosphorus and toxics loadings and the lake have been identified and acted upon. The importance of habitat linkages, such as the lake fish species that reproduce in coastal wetlands or tributary streams, and the effects of watershed forest cover and land use on those linkages must be more strongly recognized.

2. Cooperative programs such as the Great Lakes Wetlands Conservation Action Plan have proven their value in directing scarce resources to priority areas for habitat protection and rehabilitation. Similar initiatives are needed for other habitat components, especially coldwater tributaries, interior forests, and habitats for species at risk. A coordinated approach to establish priority sites for rehabilitation and to direct resources from multiple sources to those sites would be beneficial and effective. Development of a consistent and workable classification system for aquatic habitat types is an important early step in this process.

3. The development of the Lake Ontario LaMP provides an opportunity to provide a broad framework to address ongoing habitat issues within offshore, nearshore, tributary and watershed areas. This framework should encourage periodic discussions to identify short-term priorities, provide coordination of agency activities, and promote forward progress in habitat conservation and rehabilitation.

4. The most appropriate landscape unit for protection and rehabilitation planning is the watershed or subwatershed, particularly in areas with intensive urban or agricultural land uses. However, the ability of conservation authorities and other agencies to develop and implement watershed and subwatershed plans has been hampered by funding cuts. Additional resources directed to this level of planning would yield significant results.

5. Forest cover within the Lake Ontario watershed is the fundamental underpinning of habitat quality, and is currently seriously deficient in most areas. Programs such as the Southern Ontario Woodlands Campaign being developed by the Federation of Ontario Naturalists (FON) should be considered as an important potential contributor to improving forest cover.

6. Long-term environmental monitoring programs are essential to tracking progress, evaluating the effectiveness of protection and rehabilitation programs, improving understanding of ecosystem dynamics, and identifying changes associated with new stressors such as climate change. Programs to monitor ecosystem change and encourage and support improved coordination of existing site-specific monitoring programs to allow comparability should continue to be developed and implemented.

7. The critical importance of groundwater to maintaining the health of tributary streams and wetlands should be recognized. A much improved information base on groundwater resources within the watershed should be developed and stronger steps to protect significant groundwater resources such as the Oak Ridges Moraine should be promoted.

8. Actions to develop new techniques to prevent and remediate aquatic habitat impacts from urban development, and to promote the implementation of known techniques such as riparian buffers and Best Management Practices should be encouraged and supported.

9. Additional documentation of the effects of lake level regulation on coastal processes and wetlands is needed, with the goal of influencing current management programs to consider ecological values.

10. Since the introduction of exotic species has been a major historic and current stressor on the Lake Ontario ecosystem, the cooperative development of strategies is critical for the prevention of further introductions and the remediation of impacts from exotic species now abundant.

11. A review is needed of the overall effectiveness of current private land stewardship and planning control programs in preventing habitat degradation, and the development of stronger incentive programs where needed should be supported.

12. The development of additional digital data bases would permit more sophisticated analyses of habitat patterns and trends, including especially up-to-date digital information on land use change, forest and wetland cover, nearshore sediments and bathymetry, and tributary physical characteristics and fish communities. Much of the currently-accessible data in these areas is outdated, incomplete, or of uncertain quality, and a significant investment in the development of current, reliable data is needed.

13. A process of adaptive management for the lake, with the maximum flexibility possible, to enable responses to super-stressors such as zebra mussels and climate change should be encouraged.

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